TRAFFIC QUARTERLY

AN INDEPENDENT JOURNAL FOR BETTER TRAFFIC

APRIL 1949

Responsibility
Speed-Zoning in Utah
Town Planning in England
Los Angeles' Freeway System
An Urban 4-Way Stop-Sign System
Psychotechnology in Traffic Research
Road-Sign Non-Uniformity in 30 States
Urban Expressways in Houston
A Statewide O-and-D Survey
Motor Vehicle Inspection

THE ENO FOUNDATION FOR HIGHWAY TRAFFIC CONTROL

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Editorial

CREDIT should be given to our Federal Government for its guidance and contribution to our present excellent network of highways and roads.

Along with state and lower sub-divisions, the Government has shared the criticism of special and opposing groups with conflicting interests.

Greatest credit is due for the foresight and effort to keep abreast of progress in automotive engineering, to foresee a new era of highway use with its growing requirements for more, faster, and safer travel.

The road builder's important participation has contributed to the high standard of his profession. Into this effort have gone the results of continuous and long years of scientific study.

We have good roads, good cars, and many good drivers. In most cases, the signs for road directions, cautions, and restrictions are also good. Where variance from accepted practices is flagrant, it has come from zeal and determination to aid and impress the driver who appreciates his moral obligation to others, and who recognizes the problems of those concerned with efficient highway use.

It is mainly for those without such feeling that we have laws and restrictions and agencies to enforce them.

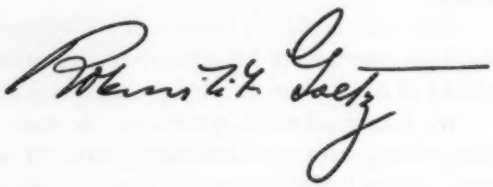
Our enforcement problem is the most difficult one in traffic regulation. With the increasing number of cars and officially qualified but often incompetent drivers, the result will necessarily be a climax of unfortunate, unwanted and useless restrictions—basically unsound and unworthy of acceptance by the driving public.

Gradually the growing efforts of traffic education will do much to improve the public attitude, but in the final analysis the keystone of efficient control will be the traffic law enforcement officer. His is the problem of bringing the offender before the law. He is the Good Samaritan of our highways.

He deserves driver cooperation and public support. Without support of the law, his role is futile. Without support of both law and public, even the most efficient officer is ineffective.

Justices of the peace can play a useful—or a harmful—role. Recently certain roadside justices have been severely criticized for unethical manners and methods. Rightly they should be the bulwark and foundation of any lawful policy of traffic regulation and control. When they deserve criticism, they stir disrespect for traffic enforcement, make the job harder for efficient traffic police.

There should be a better understanding of the problem of the traffic officer. In his inability, not of his own choice, to obtain honest and appropriate action on minor offenses, he is frustrated by an insurmountable problem of the public's growing lack of respect for all traffic laws. The enforcement officer deserves more sympathy than he gets.



Development of a Freeway System in Los Angeles Metropolitan Area

HUGO H. WINTER

Mr. Winter is Street and Parkway Design Engineer of the Bureau of Engineering, City of Los Angeles, California. He has been continuously engaged in development of the freeway plan for the Los Angeles area since 1937, first in traffic and transit surveys leading up to formulation of the plan, and since that time in the actual planning and design of units of the freeway system. He is a registered civil and structural engineer in California, a member of the American Society of Civil Engineers. He is a member of the Executive Committee of the City Planning Division of ASCE, and a member of the project committee of the Highway Research Board studying "Effect of Controlled Access Expressways on Urban Areas."

THE present freeway construction program in the Los Angeles Metropolitan Area is the direct outgrowth of extensive and cooperative planning on the part of many individuals and organizations. It follows a period of almost two decades during which a vast program of major traffic street opening and widening was carried on at an expenditure of well over $400,000,000.

While this system of major traffic streets has been of great value to the area, it has not solved the traffic and transit problem. Rapid growth of the area has caused traffic and transit demands to exceed the additional facilities it has been possible to supply.

In 1937, three organizations decided independently and almost concurrently that something of a major nature should be done about the growing traffic congestion. The Automobile Club of Southern California conducted its own traffic survey and proposed the construction of a "motorway" system. The City Engineer of Los Angeles assigned members of his staff, including the writer, to a comprehensive study of the problem.

A group of citizens organized as the Citizens Transportation Survey Committee raised funds to retain consulting engineers. The efforts of this group were given official status in 1938 with the ap-

pointment of a "Transportation Engineering Board" by the Mayor of Los Angeles. This Board consisted of the City Engineer, Mr. Lloyd Aldrich, as Chairman, and K. Charles Bean, Chief Engineer Board of Public Utilities and Transportation, and the Stone and Webster Engineering Corporation, consulting engineers for the Citizens Committee, as members. Its purpose was to conduct a comprehensive traffic and transit survey, to analyze the findings thereof and to recommend measures for alleviating the traffic and transit problem.

As the result of an eighteen months survey and study, this Board published a report in December 1939 entitled "A Transit Program for the Los Angeles Metropolitan Area." This report, because of the tremendous program recommended therein, was not immediately adopted by official bodies, but eventually it has had almost universal acceptance and is now the basic program of development for the area.

A brief review of the phenomenal growth of the Los Angeles Metropolitan Area in population, and use of the motor vehicle as a transportation medium will be helpful in understanding the reasons for the recommendations of the Transportation Engineering Board.

The area includes 1541 square miles. Part of it extends into the adjoining counties of San Bernardino and Orange. There are fifty-four incorporated cities in the area. Widespread development was encouraged by the early construction of an extensive interurban electric railway system radiating from the center of the City of Los Angeles to all parts of the area. Within the City of Los Angeles, local street car lines were likewise extended far beyond the bounds of existing development into lands then devoted to farming and pastoral uses.

With the development of the motor vehicle, further decentralization and distribution of population was encouraged. Because of favorable climatic conditions, the private automobile is a dependable means of transportation in this area and people were therefore able to locate homes and establishments without regard to established transit routes. Thus a low density, predominantly single

family dwelling pattern was set which has persisted to the present time, exercising a wide influence on the development of the area.

Since 1910, the area has grown from a population of 600,000 persons with little more than climate and scenic attractions to offer to an area having an estimated population of 4,280,000 persons and vast industrial and agricultural activities. The number of automobiles has likewise increased in the same period from 40,000 to 1,450,000 or to more than one car for every three persons. It is estimated that 80 per cent of the passenger-miles of travel of the area is supplied by the private automobile.

The Transportation Engineering Board report could not but recognize the predominance of the motor vehicle as a means of transit but it also stressed the desirability of encouraging greater use of mass transit facilities. It recognized that the traffic problem could not be solved apart from the transportation problem. Overall speeds and safety under existing conditions were being severely reduced due to the many intersections of traffic and transit on the surface streets. The report concluded that the vital element lacking in the area's transportation system was the ability to cover the long distances at satisfactory speeds. Its specific basic recommendations were as follows:

1. The progressive construction of a system of grade separated highways or freeways within the area as the most practical means of accomplishing the desired rapid transit for both the private automobile and mass transit.

2. The provision of special facilities to permit the operation of express buses along the freeways which with limited operation would provide an attractive rapid mass transit service at a minimum cost to the public.

3. The eventual construction, as the area continued to grow, of a partial Rail Rapid Transit System to serve those sections of the area most densely populated. A combination of downtown subways with rail lines along the median strips of certain freeways was recommended.

4. The coordination of surface and rapid transit facilities to provide a unified transit operation.

Present Status

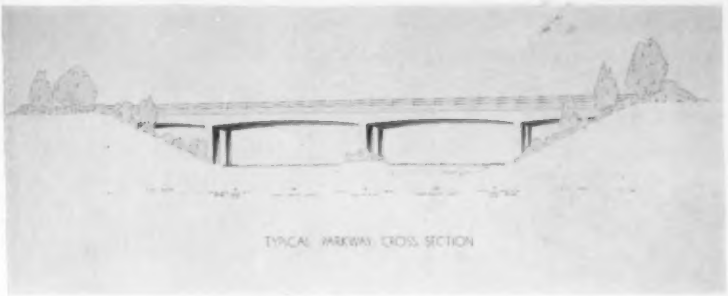
The freeway system recommended in the Report, with minor changes and additions due to natural changes in the area, has been officially adopted by Los Angeles City and County and progressively by many of the other cities of the area. The freeway routes which follow or are substitutes for State Highway routes through the area have been adopted by the State. The standards and type of construction proposed for these freeways agree closely with those desired by the State for the permanent development of their urban highways.

Thus in 1939 and 1940 the first State units of the freeway system were placed under construction.

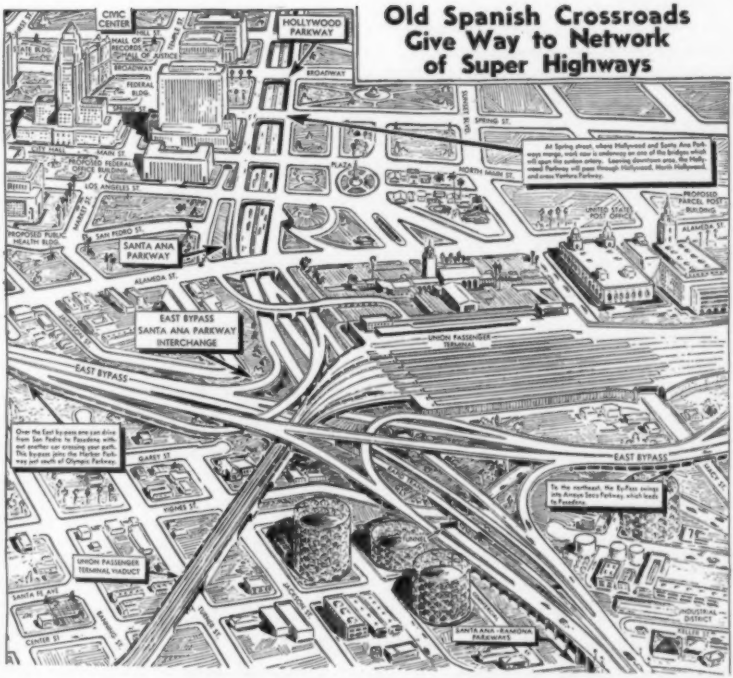
The 5.8 mile section of the Arroyo Seco Parkway and the 1.14 mile section of the Hollywood Parkway from Highland to Barham Boulevard were almost simultaneously opened to traffic on December 30 and 31, 1940. Each has been subsequently extended, the Arroyo Seco an additional 1.8 miles southerly to Adobe Street and the Hollywood Parkway, northerly to Vineland Avenue an additional 1.64 miles. In the eight years that these sections have been open, they have proven to be invaluable assets to traffic and have set an enviable safety record. With their natural setting and attractive landscaping they have done much to sell the idea of freeways of a parkway type to the community.

The 1.97 mile section of the Ramona Parkway from Santa Ana Parkway to East City Boundary of Los Angeles was begun in 1940 and completed in 1944 after being delayed several years by the war. Right of way has been purchased for much of the length of this freeway in the unincorporated areas east of Los Angeles, but no further construction has been started.

Freeway agreements for the Hollywood and Santa Ana Parkways from Vineland Avenue to East City Boundary within the City of Los Angeles and for several miles within the County have been executed, the first agreement having been signed in December, 1941. Construction on the 12.89 miles within the City was delayed by the war and by difficulties in clearing the right of way of essential housing but is now actively underway with 4.3 miles now actually open to traffic.



Parkway Bridge Design


Old Spanish Crossroads Give Way to Network of Super Highways
CIVIC CENTER
HOLLYWOOD PARKWAY
BROADWAY
SPRING ST
NORTH MAIN ST
PLAZA
LOS ANGELES ST
SAN PEDRO ST
SANTA ANA PARKWAY
ALAMEDA ST.
EAST BYPASS SANTA ANA PARKWAY INTERCHANGE
EAST BYPASS
UNION PASSENGER TERMINAL
PROPOSED PARCEL POST BUILDING
UNITED STATES POST OFFICE
GAREY ST
VIGNES ST
UNION PASSENGER TERMINAL VIADUCT
SANTA FE AVE
CENTER ST
SANTA ANA - RAMONA PARKWAYS
INDUSTRIAL DISTRICT
At Spring street, where Hollywood and Santa Ana Park ways merge, work now is underway on one of the bridges which will span the sunken artery. Leaving downtown area, the Holly wood Parkway will pass through Hollywood, North Hollywood, and cross Ventura Parkway.
Over the East by-pass one can drive from San Pedro to Pasadena with out another car crossing your path. This by-pass joins the Harbor Park ways just south of Olympic Parkway.
To the northeast, the By-Pass swings into Arroyo Seco Parkway which leads to Pasadena.

A 3.5 mile section of the Terminal Island Freeway and .80 mile section of Pacific Coast Parkway were built as Naval access road projects during and immediately following the war.

Twenty-nine miles of freeways are now completed or under construction in the Area and it is estimated that approximately $70,000,000 had been spent on these sections as of July 1, 1948.

Future Development Program

Passage of the "Collier-Burns Highway Act of 1947" by the state legislature increased the state gas tax from 3 cents to 4½ cents and increased truck levies and motor vehicle registration fees thus providing considerable additional revenue for overcoming critical deficiencies in the state's highway system. Much of these funds are available for freeway construction in the metropolitan areas of the State.

Active planning is now in progress on sections of the Harbor Parkway; the Inglewood Parkway, the Riverside Parkway, the East By-pass, the Santa Monica Parkway, the Olympic Parkway and Sepulveda Parkway all of which are state units of the freeway system. Studies are being conducted on additional routes in order to shape new subdivisions and development of private and public properties to the freeway plan as much as possible.

It has been the hope of highway officials to complete 165 miles of freeways in the Los Angeles Metropolitan Area in a 10-year period. Increasing costs of acquisition and construction probably will delay the accomplishment of this program even with the additional highway funds which have been provided.

Progressive construction of the units of the freeway system will be carried on as rapidly as funds permit.

Progress in Design Standards

It has been accepted as fundamental that the freeways in Los Angeles should conform with the highest standards of design, taking full advantage of new research and recent experience. The Arroyo Seco Parkway and the Cahuenga Pass section of the Hollywood Parkway

when opened to traffic in 1940 represented a long advance over any of the existing highways in this area. Much research in motor car behavior has since been made available, and the freeways now in the design stage will consequently be of higher standard and thus even safer and more useful. The completed parkways have given a

splendid account of themselves in safety, capacity and convenience, and their very deficiencies, which are minor, are of considerable value in pointing the way to better design, and in overcoming the inertia of engineers and public authorities in the adoption of new practices.

The principal gains resulting directly from our experience with these parkways fall under three general heads:

1. A broadened view of engineering economics. Relatively small savings in first cost have sometimes permanently impaired the value of the facilities as a whole, and serious doubts are cast on the traditional doctrine of the cautious engineer that best economic practice consists in spending the smallest sum that will construct the minimum improvement to meet a conservatively estimated need.

2. Estimates of traffic use, required to justify the building of a new highway, have normally been conservative, as they should be. However it has been found that a new freeway generates new traffic beyond the foreseeable probabilities, and estimates of traffic use which are too conservative may result in the construction of inadequate facilities. Part of the unforseen traffic load may be due to a warping of the traffic pattern that will be remedied with the extension of the system, but since temporary conditions of this sort may persist for several years, they must be allowed their due importance.

3. The safety of large volumes of high speed traffic demands the most careful planning and the acceptance of greater than minimum widths, and better than minimum cross sectional design as normal practice.

To reduce these general conclusions to more specific form, our experience with the early parkways has modified, or emphasized the need to modify, our methods of design in many particulars.

New parkways are being designed in close agreement with the recommendations of the Association of State Highway Officials as to the design of horizontal and vertical curves. If there seems to be strong reason for using a sub-standard design to solve a particularly knotty problem, the temptation to do so is firmly resisted. Much of the value of high standards lies in the consistent application of these standards and a small deviation may sometimes create a hazard of surprise out of all proportion to its theoretically minor nature.

The wisdom of using wide median strips, landscaped to reduce headlight glare and equipped with non-mountable curbs, has been demonstrated. Emergency parking lanes for disabled or halted vehicles are now being provided on the right, surfaced for safety but of a cross section that will discourage their use by impatient motorists as extra lanes of travel.

The importance of such lanes to the safety and traffic capacity of the through roadways justifies their continuous construction except where they are interrupted by ramps. Thought has been given to the construction of an additional emergency lane on the left side of roadways exceeding three traveled lanes in width, but this presents new problems and no definite policy has been adopted.

The value of flat side slopes, that is two horizontal to one vertical or flatter, has been made clear. In addition to the aesthetic virtues of good landscaping, the improved sight distance at horizontal curves, the driver's feeling of greater security, and demonstrable economies in erosion control and slope maintenance are important advantages to balance against land and grading costs. Generous side clearances of structures to insure adequate sight distances are also considered to be well worth the added cost.

Insufficient lengths of accelerating and decelerating lanes can be a serious matter to both through and turning traffic, and in this respect the A.A.S.H.O. recommendations are accepted as minima. Our designs now are based on the location of all entering and leaving movements at the right side of the road except where the estimated traffic volumes are nearly equal. In this connection the adequacy of existing directional signing is now being reviewed, and a definite policy will doubtless be formulated calling for better spacing and visibility of signs and for treating signing as a problem of original design, deserving of the most serious consideration.

The present traffic loads, exceeding 86,000 cars a day, carried by the 8-lane portions of the Arroyo Seco Parkway and the Cahuenga Pass section of the Hollywood Parkway, can only be relieved by the construction of other parkways to siphon off some of the traffic. This brings into sharp relief the need of extending the system as rapidly as possible.

Redesign of Surface Streets

The transition between parkway and surface street conditions, and the physical treatment of the adjacent streets themselves where they are cut off, redirected, or brought in contact with the parkways, are highly specialized problems of street planning and design, but the usual engineering methods provide the proper solutions. The new problems created by the construction of the parkways themselves are largely concerned with the movements of traffic, and these demand research, analysis, sound judgment, and a strong element of prophecy. Important basic information is lacking, and even the knowledge of what information is most pertinent to the solution of these problems is limited by our relatively short experience.

In the case of the Arroyo Seco Parkway, a few paralleling surface streets formerly carried the through traffic. Construction of the parkway invited heavy additional traffic loads to the parkway and after the first year, in which traffic shifted back and forth, it appeared that the parkway had permanently diverted about 50% of the street traffic. This was of great benefit to the merchants along Figueroa Street, formerly one of the through traffic streets, since the diverted traffic comprised that portion of the street load which caused congestion without contributing to the fronting business establishments.

How far this proportion of diversion may prove to be typical is a matter of speculation. Can 50 per cent be accepted as a normal reduction in street traffic where there are numerous heavily loaded parallel streets? If so, how wide is the range of influence, and how will the drawing power of the parkway decrease with distance? The answers to these questions can not as yet be positive, or be formulated into a rule of thumb, but further experience will certainly add to our knowledge and ability to predict.

Somewhat more definitely we can determine the need of street widenings and realignments. Because of the heavy distribution from the proposed East By-pass in the Central Business District, a number of ramps are designed to empty into or draw traffic from Stanford Avenue, a paralleling business street. Existing and potential traffic

loading of this artery and the probable contributions of the parkway can be estimated, and the necessary number of lanes can be obtained by widening the street. Distribution of traffic to the Central Business District from the same parkway and the Harbor Parkway on the west has also dictated the establishment of pairs of one-way streets running east and west, permitting more and more efficient ramps than were possible with full two-way operation. These are examples in an established district, where conditions may be foreseen with some assurance.

The location of ramps and the relocation of surface streets must be based upon similar studies of existing traffic patterns, probable changes in population densities, and the potential development of new sources of traffic demand. The last named element presents extraordinary difficulties in advance planning because of the phenomenal growth of the Los Angeles region.

A sudden development such as the Crenshaw Boulevard shopping center cannot be foreseen very far in advance. Two major department stores have erected large units here with ample off-street parking, numerous satellites and large areas of multiple dwelling units have sprung up around them. The resulting effect on the traffic pattern has been tremendous and has extended for several miles in all directions. When development takes place before parkway locations are completed, plans can usually be revised to account for changed conditions. When the parkway serving an area is built or in final design, it becomes a major factor in the area's development, so that in the long run the two apparently divergent conditions are resolved.

In general, the frequency of crossings is determined by the character of the district traversed, and their position by the traffic carrying importance of the cross streets and the locations of neighborhood facilities such as schools, shopping centers, et cetera. In densely developed districts, a quarter mile between vehicular crossings, with pedestrian crossings midway between each pair of bridges is taken as the desirable standard for complete cross connection. In outlying, undeveloped districts, these lengths may be doubled, and in any district they are subject to considerable variation to meet the existing and probable local conditions.

Where crossings occur every quarter mile it is possible to use paralleling one-way service roads or outer highways, and this design frequently proves desirable in eliminating cul-de-sac streets and in completing a very efficient pattern of ramp services. With less frequent crossings two-way service roads are usually required and the ramp system becomes more complex.

Mixed Traffic And Rapid Transit

It has been made clear that rail rapid transit for the Los Angeles region will be achieved at the lowest total cost if rail lines can be built in the median strips of the appropriate freeways. This method would take advantage of the grade-separated rights of way without the great additional cost entailed by construction in separate right of way or covered subway. The question of whether rail rapid transit is justified or can be financed has not as yet been answered, and since highway funds can not be used for that purpose, the answer, and the money, will have to come from other sources. Enabling legislation which will permit the formation of a Rail Rapid Transit District is now before the State Legislature which if successful will permit the determination of this matter.

In the meanwhile, tentative plans for the affected freeways are based on providing adequate median strip widths and bridge clearances, including one-mile spacing of stations. In the event that one or all of these freeways reaches final design before money is assured for the purchase of the additional right of way and the extra construction needed for the rapid transit lines, it will be necessary to reduce the freeway's width and let the rail line find its own course elsewhere. It is easier to reduce the width at that time than to expand it, since an expanded width of right of way frequently entails extensive relocation.

The question at issue is not one of building rapid transit facilities now or never, but is entirely one of ultimate cost. If the need for rapid transit is twenty years away, then the money spent today for rights of way and bridges would return no dividends of usefulness in the interim. It may under those conditions be wiser economy to let the rapid transit lines pay their own way when the need is great enough to justify their construction.

The use of freeways by express buses is expected to be widespread and the cost of loading facilities has thus far been borne by the City on the assumption that reimbursement will be made from franchise fees. A necessary regulation will require the use of buses having modern operating characteristics, so that buses will not conflict with or hamper the normal flow of private vehicles along the freeways.

The use of some freeways by trucks is also to be expected, since the California law provides that state highways must be open to use by all types of traffic unless suitable paralleling routes are available. In some cases then, other highways may be designated as truck routes, but in certain locations as through Sepulveda Canyon, all of the space is pre-empted by the freeway and no paralleling truck route of comparable length can be found. In these instances the freeway will necessarily carry both private and commercial traffic and doubtless buses as well.

Ramps are being designed throughout the system with lane widths and curb return radii sufficient to accommodate trucks. On the parkways themselves, grades are kept to a minimum as a matter of course, and no other special design features for trucks are needed. Some thought has been given to the possibility of adding an additional lane for trucks on long up grades, but so far this has not been incorporated in any existing plan. Analyses of the probable proportions of commercial traffic will be made wherever it appears desirable.

Benefits of Freeways to Motorists and Others

The function of the completed system of freeways is threefold: first, to provide needed routes of travel to supplement the street system so that fast, long distance traffic can move freely; second, to achieve in itself the highest degree of efficiency, traffic capacity and safety; and third, by freeing the surface streets of their dangerous overburden of through traffic, to render them safe and useful for their proper purposes.

The first of these is a long term goal, since the construction of the system will be in progress for at least another twenty years. By orderly programming of construction to give first relief to the most con-

gested streets, much can be accomplished in the early years, and with the opening to traffic of each new project an important unit will be added to the sum of the City's transportation system.

The benefits accruing to the motorists using the freeways are many, and not all of them are enumerated here. The most apparent of these is the freedom of movement and the elimination of cross traffic delays, but far more important is the safety factor. Almost 90 per cent of traffic fatalities in Los Angeles normally result from accidents of four general categories.

These are vehicle-pedestrian collisions, head-on collisions, intersection accidents and accidents involving cars entering or leaving driveways or curb parking spaces. The design of freeways is specifically directed toward the elimination of these categories, and the accident records of the existing freeways are correspondingly good. Surface highways carrying comparable traffic loads have had five to eight times as many accidents per vehicle mile as the Arroyo Seco Parkway, and greater safety is being built into the freeways constructed under current standards.

The measurable economies in the actual cost of operating a passenger car on a parkway as against surface streets with an average of five stops to the mile is estimated to be in excess of one cent a mile. Delay estimates of one cent a minute for passenger cars and 3 cents a minute for commercial vehicles are in common use. There are still other economies, more difficult to appraise in terms of money but which are real and tangible in the end result.

Safer highways will result in lowered accident insurance rates, since these belatedly reflect accident experience. The wear and tear suffered by automobiles and the damaging nervous strain of drivers owing directly to traffic congestion are not measurable in money, but they are no less real.

In addition to the direct profits gained by those who use the parkways, construction of the system will be of inestimable value to all residents of the region. By siphoning off the through traffic the surface street system will be returned to its proper use, which is the service of the land. Business developments will perhaps derive the most benefit from this, in spite of the quite current belief of many businessmen that passing traffic and profits go hand in hand. The

moment congestion appears in an artery of traffic, business along its course begins to feel the ill effects, and the elimination of that part of the overload which consists of fast, long distance traffic is an immediate remedy.

Residential and all other land uses are unquestionably helped by better transportation, and it is felt that in general property values will be increased in all of the affected areas as the system is extended. The stabilizing of the pattern of land use and the consequent and desirable stabilizing of property values will follow naturally.

In short, the completion of the parkway system in the Los Angeles region is of such manifest importance that every effort should be made to expedite each phase of the program.

Highway Speed Zoning and Control as Practiced in State of Utah

HARRY S. WRIGHT

Mr. Wright is Chief Traffic and Safety Engineer for the State Road Commission of Utah. From 1940 until 1948 he was also Consulting Engineer for Midvale City, Utah. From 1927 to 1929 he was a practicing Civil Engineer. From 1929 to 1945 he was Office Engineer and Chief Draftsman for the Utah State Road Commission. He assumed his present post in 1945.

THE value of uniformity in traffic control practices has proved itself to me with experience. The program and practices for proper speed zoning and control are no exception to uniformity; rather they substantiate it.

The goal of the program to standardize speed zoning practices can more readily be gained if there is a centralized power at the state level to control, advise and direct the program. The directing and control of the program should be placed in one authoritative and competent agency's hands, whether that agency be governmental or not. The program should be uniform in its application, yet with sufficient flexibility to meet local conditions.

That, of course, requires those who shall direct such a program to be completely capable in traffic engineering, and thoroughly schooled in human relations. To these attributes should be added the conviction that in the field of engineering, traffic engineering is highly important. Traffic engineering bears a responsibility for promoting safe and expeditious traffic.

Following national recommendations, the State of Utah adopted the plan wherein full jurisdiction in traffic engineering procedure, including speed control, was placed in the authority of the Road Commission for all state highways. This Commission was tightly bound by law to traffic engineering principles. The following is an excerpt from Utah laws governing speeds, giving basic requirements, and power of adjustment or change:

"Speed Laws of Utah Sec. 57–7–113–Restrictions as to Speed–Reasonable Under Conditions–Maximums.

(b) Where no special hazard exists the following speeds shall be lawful, but any speed in excess of said limits shall be prima facie evidence that the speed is not reasonable or prudent and that it is unlawful:

(1) Twenty miles per hour.

Upon meeting or overtaking any school bus which has stopped on the highway for the purpose of receiving or discharging any school children, provided, such bus bears upon the front and rear thereof a plainly visible sign containing the words School Bus in letters not less than 4 inches in height which can be removed or covered when the vehicle is not in use as a school bus.

When passing a school building or the grounds thereof during school recess or while children are going to or leaving school during opening or closing hours; provided, that local authorities may require a complete stop before passing a school building or grounds at any of said periods.

(2) Twenty-five miles per hour in any business or residence district.

(3) Sixty miles per hour in other locations during the day time.

(4) Fifty miles per hour in such other locations during the nighttime.

Daytime means from a half hour before sunrise to a half hour after sunset. Nighttime means at any other hour.

"Sec. 57–7–114 Id. Prima Facie Limit.

Whenever the State Road Commission shall determine, upon the basis of an engineering and traffic investigation, that any prima facie speed hereinbefore set forth is greater or less than is reasonable or safe under the conditions found to exist at any intersection or other place or upon any part of a highway, said commission may determine and declare a reasonable and safe prima facie speed limit thereat which shall be effective when appropriate signs giving notice thereof are erected at such intersection or other place or part of the highway.

"Sec. 57–7–115 Id. Local Authorities May Declare Prima Facie Limit.

(c) Alteration of prima facie limits on state highways or extensions thereof in a municipality by local authorities shall not be effective until such alteration has been approved by the State Road Commission."

These laws are specific in prescribing procedure and methods in this field for county roads and city streets.

This plan was not adopted arbitrarily, not with ideas of state domination, but to give genuine aid through concentrated efforts that could not be obtained through a loose-jointed independent program. It was also realized that traffic is no longer a local problem, but statewide, national and even international in its scope.

The Significance of the Law

The full significance of this plan was more fully realized at the conclusion of the war. During the war period, traffic problems in Utah were less intense. Personnel in the Traffic Engineering Department was limited. As a result the program lagged in intensity. Speed zones were regarded with little respect by our motorists. Unreasonableness and poor markings lowered their value. It then became our task to reassure the traveling public by an action program that the numerical value on the speed sign was important and should be obeyed. The motor vehicle operator's confidence needed restoration, by showing him that the past fallacy of "fooling some of the people part of the time" in speed zoning was at an end, and assure him that speed zones would be safe, reasonable and would move traffic with as little delay as possible.

Inasmuch as careful speed zoning can eliminate many accidents, concern and care should be given in establishing the zone. It is as unethical for a traffic engineer to be careless and "pressure-satisfying" in posting an incorrect and unreasonable zone, as it is for a bridge engineer to turn his back upon faulty construction and poor materials.

Establishing Correct Speed Zones

It is not necessary to describe in detail the mechanics of the correct methods to be followed in establishing a speed zone. These procedures have been set up by experts with wide experience and are available in accepted publications. It is sufficient to say that the zone must first be safe, but reasonable in its demand for safety, so it can

be enforced—always bearing in mind that its purpose is to move traffic and not retard it.

In Utah, we have used the following basic principles in determining speeds in order to be sure of establishing the correct speed zone based on the following fundamental principles: Safety, reason, efficiency.

Detailed steps necessary to obtain these fundamentals are:

1. The physical design of the highway and its ability to sustain a given speed.
2. Relationship of adjacent property uses to highway design.
3. Critical speed at points of danger.
   (a) Curves
   (b) Points of limited sight distance
   (c) Intersections
   (d) Activity centers.
4. Safe speed on curves. (By ball bank indicator tests.)
5. Existing speeds of highway users. (Spot speed checks using automatic timing devices.)
6. The use of the highway (By vehicles, pedestrian and others.)
7. Accident experience.

Everyone who drives an automobile is a traffic expert. So it is often necessary to "sell" to the public in general, and to civic groups, and civil authorities, in particular, the wisdom of our speed-zoning practices. The fallacies of low speed-zones, as well as the dangers of extremely high speed-zones, must be pointed out. Factual truths are the best weapons with which to win agreement.

Example: The small community of South Salt Lake, whose population is about 5,000, situated adjacent to Salt Lake City on our

heaviest traveled highway US-91 (20,000 vehicles daily.) This city had petitioned vigorously through pressure groups for a reduction in its speed regulation. The request was unjustified.

Our investigation had shown that the critical speed at points of danger was seven miles an hour above the request with only one exception. Motorists themselves had realized this as shown in the eighty-five percentile speed of our checks, this being 11.5 miles an hour above the request. The accident experience was normal for the volume of traffic. It was our opinion that to reduce speeds below that already posted would seriously retard traffic and result in increased accidents.

In addition to these facts, speeds checks made formerly when the lower speed was posted, showed the eighty-five percentile speed at 10/9 miles per hour above the posting. You will note a differentiation of only 0.6 of a mile per hour between the two checks, each with a different posting. This clearly indicates the fallacy of the low posting as recognized by highway users. It is needless to say that peace officers did not enforce the low regulation.

Applying the principle of human engineering as mentioned previously, we met with the interested groups and presented to them the factual truths. We also enlightened them on our speed zoning methods, showing them that guessing or estimating was not used. This meeting resulted in gaining our objectives and winning supporters to the speed zoning program. Perhaps one may think such a procedure too time-consuming for busy traffic engineers. I believe it is not too time-consuming if it will save lives, reduce accidents, or win friends to our cause.

Posting the Zone

After a zone has been prudently established, it should be so posted as to readily and continually inform the traveling public as to requirements. No motorist should be subjected to punishment for disobedience to a law that he has not been properly informed of.

Inasmuch as motorists' attentions are diverted to many channels, the speed sign must be easily discerned and quickly read. Its position and shape can make it readily discerned, but the size of the sign and the pattern of the lettering make it quickly readable. This is primary.

Example: Recently we changed the lettering design on our speed signs from

By removing the word "miles" we are able to increase the size of the wording considerably, particularly the important numerical value. This was increased from 10 inches to 14½ inches. The overall size of the sign was not increased. Yet its effectiveness and readability was increased tremendously for both day and night. The larger type letter and the more simple design gave it a flash or punch effect that gave us better driver compliance.

Increased Size of Lettering Reduces Speed

An experimental section was posted with this new larger sign on US-91 between Salt Lake and Ogden. This is one of our heaviest traveled highways (15,000 vehicles daily) for a distance of forty miles.

Before this posting, vehicular speeds were running slightly in excess of the speed we considered as safe. The accident experience was beginning to rise and we were concerned as to what necessary steps we should take to reduce the vehicular speeds to a reasonable normal.

The result of our flash-type posting was an immediate average reduction in the 85 percentile speed of 3.3 miles an hour. A check

over the same course made three months later still showed a reduction of 2.9 miles per hour for the average 85 percentile speed. Enforcement officers reported to us that judges stated to them that fewer claims were made by offending speed violators that they (the violators) were unable to see the speed signs.

Repeat Signs

As previously stated, compliance with our zone regulation is paramount, therefore sufficient signs should be placed to inform the vehicle operator of the speed required. In restricted areas, marking the beginning and end of the zone is not sufficient. Where reasonable high-speed approaches are adjacent to restricted zones, we have used effectively a repeat sign slightly larger in size, approximately 750 feet, beyond the first sign. At reasonable distances within the restricted zone, additional signs should be placed.

This type of signing has dual value. First, if the driver does not see the first sign, there is an opportunity that the second sign will be observed. Secondly, the second or additional sign can act as a reminder to the motorist as he drives through the zone. We have used this repeat system with success in many of our isolated cities.

Transition Speed Zoning

Utah is semi-arid, and typical of this geographical type, about eighty per cent of the cities are intermittently located with open spaces between. The pattern is generally the same, open highway for miles on end, then a quick transition into semi-residential and business, with a reverse of this pattern on the way out.

Motorists traveling the open highways between these cities attain and maintain extremely high speeds for considerable distances. The relative ease with which they travel in safety over long stretches makes it difficult for them to properly adjust to a safe speed while passing through the restricted area. The result, of course, is conflict between the fast through motorist and local traffic, both vehicles and pedestrians.

To overcome this condition it is necessary to effect an automatic

reaction upon the driver by taking him through a step-down process of high to medium to low speed over a reasonable distance. This we have called the transition zone. To make this zone appear reasonable in its demand to the approaching motorist, the transition or middle zone is posted in the semi-residential or semi-congested area. (The approach to the business area.) The speeds, of course, must always be established in an engineering manner, fitting the actual conditions. They should never be arbitrarily set.

In the actual posting of this type of zone, we have used the repeat method as previously mentioned, with sufficient intermittent signs. The effectiveness of this type of zoning was fully realized in the little community of Grantsville near the easterly terminus of the Salt Lake road. Approach speeds to this community are extremely high, many motorists driving in excess of 70 miles per hour. At this location, the eighty-five percentile speed was reduced 12.1 miles per hour through the short business area, by well-marked transition zoning.

Other Types of Zoning

In the speed transition from high to lower speed we have also used effectively the advance warning sign—announcing to the motorists by super-signing that a reduced speed zone is ahead a given distance. However, we have found that the effect of this type of treatment is reduced considerably if repeated in close proximity. We have also realized the folly of misuse.

Some of you may have had difficulty in getting respect for, or compliance with temporary speed zones in areas of construction, etc. We had despaired of getting satisfactory results at such locations. It may be interesting to note, however that better results were obtained by switching from our standard speed sign with a temporary plate attached, to a diamond-shaped sign 36 inches in size, reading SLOW TO——MILES. The legal demand was changed to a reasonable request. This method of appeal was a substantiation of our former findings that the average driver will respond to a reasonable appeal quicker than he will to a demand.

Example: As an illustration of this, during the early months of the war, a direct appeal was made to motor vehicle operators to re-

duce their speed to approximately 35 miles an hour. It was pointed out to them that the purpose of this was to conserve gasoline, tires, and motor vehicle equipment as a means towards winning the war. In all instances it was an appeal of reason. The operators of motor vehicles repsonded to this reasonable request and speeds were reduced and our objective was accomplished. However, after a few months, it was felt by certain groups that we should enact a law demanding that speeds be reduced.

Over the objection of the most capable and authoritative traffic leaders in our state, this law was enacted. It was now demanded of motor vehicle operators that they should travel at a rate of 35 miles an hour.

This demand reacted as we had anticipated. Speeds began to increase immediately. When an appeal to reason was made, the American responded; but when force was used, he refused to do the unreasonable.

Cost of Speed Zoning

The cost of speed zoning on state highways, both in urban and rural areas, is borne by the State Road Commission. The original installation of these zones is paid for from the Traffic Engineering Budget. The maintenance of the signs, posts, etc. for the established zone is borne by the Maintenance Department of the State Road Commission. All signs are installed and maintained by the State. The estimated cost of the standard sign face is $6.50. Complete in place with posts and bolts, the total cost is $10.16.

At the present time, we are carrying out investigations as to the advisability of removing speed restrictions in open country and enentirely concentrating our efforts upon zoning where reduction in speeds is necessary. The result will be surprising to most traffic engineers.

Wise speed zoning, carried out in a thorough traffic engineering manner, will save lives, money, and reduce considerably our accident experience. This has been proved. If this type of program were followed throughout the nation, speed zoning would win approval of the traveling public.

A Four-Way Stop-Sign System at Urban Intersections

COOPER McEACHERN

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"THE proper . . . application of traffic control devices, despite the existence of accepted standards, is still subject to much uncertainty and even to open disagreement."[1]

In the application of any type of traffic control at intersections, care should be taken to evaluate properly the effects of the proposed device on the movement of vehicles and pedestrians.

The stop-sign is considered a useful, important tool of the traffic engineer in reducing accidents and promoting orderly traffic. Little effort however, has been expended to study the ramifications involved in the various uses of the stop-sign. Relative inexpensiveness of stop-sign installations has contributed materially to this laxness of effort.

One use is the four-way stop, when traffic on all four approaches to an intersection is required to halt. This use is controversial among traffic engineers and officials. Different warrants have been used and others suggested for erecting these four-way signs; but, unfortunately, the warrants have not come from comprehensive study of the factors involved.

This article will (1) present in an objective manner information supplied by cities relative to the use of the four-way stop, (2) analyze accident records at intersections in an effort to determine the effectiveness of four-way stops as an accident-reducing measure, and

1 *Uses of Traffic Accident Records*, Comm. on Uses of Developed Information, National Conference on Uniform Traffic Accident Statistics, 1948, p. 92. Published by the Eno Foundation, Saugatuck, Conn.

(3) suggest a definite pattern in the behavior of traffic at an intersection controlled by four-way stop signs.

SURVEY OF THE USE OF FOUR-WAY STOP CONTROL

In 1947 information on the use of four-way stop control was sought from traffic officials in seventy-five cities with populations of 50,000 or greater. Of the cities contacted, thirty-eight, or 51 per cent, replied.

Twenty-one, or 55 per cent, of the cities indicated the use of four-way stop control, while six cities, or 16 per cent, reported having tried the control and discontinued its use. The remaining 29 per cent do not use four-way stops and do not have any record that such control has ever been tried.

There was wide variance among the cities with regard to the extent of usage of the four-way stop. One city in the 500,000 population group reported 101 four-way stop intersections while another city in the 250,000 to 500,000 population group reported only one four-way stop installation. In general, higher usages were reported by cities in the mid-western and western sections of the country.

Warrants

Warrants for four-way stops signs have not been analyzed and as readily accepted as warrants for traffic signals. With the increased use of this method of intersection control there is a definite need for specific warrants or for data that will prove that the four-way stop is not warranted.

As reported by the cities, the warrants vary considerably. The majority of these warrants are designated by generalities—accidents, pedestrian safety—with no specific values applied to each warrant. In most cases, several warrants were used collectively, but the warrant used by most cities is the high-accident frequency at intersections controlled by two directional stop-signs. Fifty per cent of the cities listed this warrant. The next most common warrants listed were pedestrian-safety and restricted-visibility or sight-distance.

Other warrants varied from expediency to speed-control of ve-

hicles. It is significant that many cities reported that four-way stops were being used in lieu of traffic signals because of a lack of funds. While public demand is not a warrant in the engineering application of the word it nevertheless has exerted a profound influence on the erection of four-way stops.

Only four cities reported the use of any definite values in describing warrants. These included speed, vehicle volumes, and the number of accidents with the former method of control.

Vehicular Right of Way

Vehicular right of way at four-way stop intersections cannot be decided as readily as in the case of a two-way stop or signalized intersection. When traffic volumes are light, it is within reason to employ the customary procedure used at non-controlled intersections with the vehicle on the right having precedence. Also, under favorable conditions a no-right-of-way or "driver control" rule may suffice. But neither of these methods is sufficient when there is considerable volume of traffic as occurs during the peak hours of traffic flow.

Of the twenty-one cities that reported the use of the four-way stop, only 38 per cent employ a "right of way" rule. In each of these cities the law that prevails is that all of the vehicles approaching the intersection shall yield the right of way to the vehicle on the right. The remaining cities, or 62 per cent of the total, reported no right of way rule in existence.

Methods of Control Prior to the Four-Way Stop

Nineteen of the twenty-one cities reported that four-way stops replaced two-way stops in most locations. Two cities employed the four-way stops in most locations. Two cities employed the four-way stop control only at locations previously without any form of traffic control. Three cities stated that four-way stops had been used to replace fixed-time signals.

As reported by the traffic engineers of the cities surveyed, the following is a summary of the reaction of the public and the law enforcement groups to the four-way stop control:

Public Reaction: Favorable in 36 per cent of the cities; unfavorable in 5 per cent of the cities; variable in 59 per cent of the cities.

Police Reaction: Favorable in 53 per cent of the cities; prefer other type control in 10 per cent of the cities; indifferent in 37 per cent of the cities.

While a survey of this type may be prejudiced, it is significant that in approximately one-half of the cities using the four-way stop, either the public or police reaction to the control is other than favorable.

Physical Aspects and Location of Stop Signs

The majority of the cities polled employ the standard twenty-four inch octagonal sign with either six or seven inch letters. All of the cities but one reported the use of the word "stop" as the sign message. The other city stated that the word "stop" with "4-way" beneath were used in that order to convey the meaning of the type of intersection to the motorist. The traffic engineer of that city is convinced that this message results in a higher degree of observance by the motorist.

The position of the stop-signs with respect to the street was reported by most officials as the property line. Two cities stated that signs were suspended over the intersection by means of a span wire in order to obtain maximum visibility and observance.

Seventeen cities reported that the four-way sign method of control is not being used. Of these, seven stated that the plan had been tried but discontinued. The reasons given for not using four-way stops varied considerably among the cities. In most instances the traffic engineers and traffic officials were opposed to this type of control. Several cities reported an increase in accident rate with four-way stops.

Legality of the Four-Way Stop

Traffic control devices lose a large part of their effectiveness unless their legal authority is definitely established and they are made to play an important role in the law enforcement program.

In a recent manual, we read:

> "It is commonly provided by law that state and local authorities, with reference to highways under their respective jurisdiction, may

designate through highways and erect stop signs at specified entrances thereto, or may designate any intersection as a stop intersection and erect like signs at one or more entrances to such intersection."[2]

Some States, however, do not incorporate in their motor vehicle laws a provision that permits local authorities to erect stop signs at all approaches to an intersection. Instead, the law in these states provides that cities may designate any highway or part thereof as a through highway. Thus, no authority is given for the erection of stop signs, unless the purpose of such erection is to provide one street as a through-street.

Of the thirty-eight cities that replied to the question concerning legal authority to erect four-way stops, twenty-six have such authority. The remaining eleven cities that have no authority may be divided into two groups:

1. Cities prevented from erecting four-way stops by state law.
2. Cities given authority by state statutes, but having outlawed the use of four-way stops by preference.

All of the cities reported that no legal action had resulted from the use of the four-way stop. However, in one of the states represented by this survey the question of legality had been subjected to judicial interpretation. In this state the law regarding the use of the stop-sign provides that stop-signs may be erected only if the signs designate the intersection of a through street. This would imply that at an urban intersection only one of two intersecting streets could be made a stop street. Three cities within that state employ the four-way control, even though the control is not a policy of the state highway commission.

Because of this extended use, the attorney general of the state was requested by the state traffic commission to supply a ruling on the intent of the state code. His ruling was that to comply with the state code only one of two intersecting highways can be desig-

[2] *Manual on Uniform Traffic Control Devices for Streets and Highways*, Joint Comm. on Uniform Traffic Control Devices, Pub. Rds. Adm., Fed. Wks. Agency, 1947, p. 10.

nated as a "through way." This decision, however, does not take issue with the traffic control device, but rather it is an interpretation of the state law.

There has been much controversy as to the legality of the four-way stop, but the above cited case was the only one found that resulted in a decision by the courts.

ACCIDENT RECORDS AT FOUR-WAY STOP LOCATIONS

"Before and after" accident data were obtained from cities for the purpose of determining if the four-way stop method of intersection control is achieving desired results; and to find out if factors were being overlooked which, if properly corrected, might result in an improvement of the former method of control instead of resorting to the four-way stop.

Data were obtained from thirty-eight intersections in four cities. An analysis of the "before and after" accident records yielded some interesting information. The trend was a decrease in the severity of accidents and a reduction in both pedestrian and vehicle accidents. It must be pointed out that the reverse was true at many of the intersections.

On the other hand, the analyses of the "before and after" periods revealed that there was no decrease in accidents during hours of darkness. Also, it was indicated that many of the "before" accidents at the above locations occurred when stop sign visibility was impaired by some obstruction or by improper location of the sign.

In summary, the study revealed that the four-way stop, though inexpensive and an expedient, is not a panacea that can be used indiscriminately. Traffic authorities in many instances are not attempting to improve the two-way stop before resorting to the use of the four-way stop. With a slight change in traffic volumes, the accident experience at four-way stop intersections varies considerably with all other conditions remaining fairly stable. The use of the "number of accidents," as is the case in many cities in the survey, without proper analysis of other factors does not prove that four-way stop signs are effective as an accident reducing measure.

BEHAVIOR PATTERNS AT A FOUR-WAY INTERSECTION

It was found from the aforementioned survey that the majority of the cities do not employ a right of way rule for vehicles at four-way stop intersections. In addition, none of the cities reported having made any delay or behavior studies at the respective intersections.

In a previous study it was found that vehicles at non-controlled intersections and at two-way stop intersections are governed by the time advantage or gap in opposing traffic.[3] This time gap was determined by recording the time an opposing vehicle is from the collision point.

At a stop-sign intersection, the minimum acceptable time gap in cross flow traffic was found to be about six seconds, and the minimum alternate clearance time between vehicles at non-controlled intersections was observed to be 2.85 seconds or about one-half the acceptable average minimum gap required for crossing.

Method of Procedure

The factors governing traffic behavior at intersections controlled with four-way stop signs are unlike those at other types of unsignalized intersections. While it has been observed in the previous study that drivers of vehicles at two-way stop intersections are governed by the time gap of opposing traffic to the collision point, a quite different situation is present at the four-way stop. At such an intersection the drivers of vehicles on all of the approaches are confronted with a stop sign. Hence, when a vehicle is stopped at a four-way stop intersection it is not possible to measure a time gap with reference to the collision point.

Observations of traffic behavior were made at an intersection in Hartford, Connecticut. The vehicles were observed to wait and flow intermittently from both directions through the intersection. If there were no opposing vehicles the movements of vehicles on a particular approach were observed to consist of a stop followed by movement through the intersection. Upon reaching the "stop line,"

[3] Greenshields, B.D., et al, *Traffic Performance at Urban Street Intersections*, (Technical Report No. 1, Yale Bureau of Highway Traffic, 1947) Chap. IV.

however, it was noticed that the motorists seemed to be affected by opposing traffic. In either case, when the vehicle crossed the stop line the stop watch was actuated, and, when the first opposing vehicle reached its respective stop line, the watch was stopped.

The reading from the watch, in seconds, was judged to be the time gap available in opposing traffic. If a driver on one of the streets proceeded into the intersection before the opposing vehicle reached the stop line on that street he was deemed to have accepted the gap *initially*. If the vehicle waited until the opposing vehicle stopped he was judged to have refused the gap *initially*.

When the driver refused the time gap initially he was beset with another decision: whether to take or relinquish the right of way. When this situation occurred, it was recorded as either a final acceptance or final refusal of the time gap available.

The same objective criterion used in the Greenshields Study was borrowed for this study; that is, it was judged that the acceptable average-minimum gap be that time gap accepted by more than 50 per cent of the drivers.

The intersection studied was local in character. The volumes on the two streets were about equal. During the peak-hour on an average day in April, 1948, the total number of vehicles entering the intersection was approximately six hundred. During the off-peak hours, when the traffic behavior observations were made, the maximum hourly volumes were from 450 to 500 vehicles. The sight-distance was equally restrictive in all directions.

Initial Acceptance of Time Gap

There were 316 cases recorded. Of this number 217 were vehicles that proceeded straight through the intersection. The remaining cases involved left and right turning maneuvers. Sixteen of the 217 vehicles were faced with a 3.5 second gap in opposing traffic and eight or 50 per cent accepted.

Seventy-eight per cent of the drivers accepted a 4.0 second or greater gap. The acceptable average-minimum gap in seconds lies between these two values. For all practical purposes the gap was judged to be four seconds.

The acceptable gaps for the converging maneuvers, left and right turns, were found to be only about one-half second less than for the conflicting maneuvers. However, since the sample of converging maneuvers recorded was considerably less than that gathered for the conflicting movements the pattern may not be as representative.

Initial Refusal of Time Gap

There were 192 cases recorded when time gaps were refused. Of the ninety-six vehicles that made a straight ahead maneuver, thirty-eight were recorded that had a one second or less time advantage over vehicles in the opposing traffic. For all practical purposes this time gap may be considered as zero, and the thirty-eight vehicles may be regarded as having arrived simultaneously with the opposing vehicles. Fifty per cent of these vehicles took precedence over the opposing vehicle. Using the average as a criterion it was obvious that vehicles at this intersection do not follow a "right of way" rule.

The general trend observed was that the larger the initial time advantage, the more often the driver takes precedence.

SUMMARY

1. While most cities do use warrants for the establishment of four-way stop intersections, the warrants are not specific; and, the single most widely used warrant is the high accident frequency at two-way stop intersections.

2. Most cities do not employ a right of way rule for vehicles at four-way stop intersections.

3. The four-way stop is usually employed at urban intersections as an intermediate treatment between the two-way stop and signal control.

4. As reported by traffic officials, the public and police reaction to the four-way stop is variable, depending upon individual locations.

5. The usual message employed on four-way stop signs is the word "stop". The use of the message "4-way stop" has not been tried extensively.

6. In most cities and states the four-way stop is considered to be a legal traffic control device.

7. The use of the four-way stop sign has shown a reduction in accidents at some locations. But the use of figures without proper analysis does not reveal a true picture.

8. There have been few attempts to improve the two-way stop control before resorting to the four-way stop.

9. Drivers stopped at a four-way stop intersection are governed by the time gap in opposing traffic—approximately four seconds, measured from the opposing vehicle to the stop line on the approach of the opposing vehicle.

10. Drivers who initially refuse to accept a time-gap in opposing traffic are governed by no right of way rule. The larger the gap refused, the more often will the driver who refuses the time gap assume the right of way or take precedence over the opposing vehicle.

A Ministry for All Town Planning in England and Wales

R. T. KENNEDY

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TODAY, Great Britain, with its Town & Country Planning Act of 1947 and its New Towns Act of 1946 has probably more comprehensive planning powers over the control of physical development than any other country. How effective those powers will be it is yet too early to say, for the 1947 Act came into operation as recently as the first of July, 1948, and the organization created for implementing the New Towns Act has, because of the economic crisis, been unable to demonstrate its effectiveness.

Town planning legislation began modestly enough as Part II of a Housing and Town Planning Act in 1909 administered by a now defunct Local Government Board. Between the two wars it was administered by the Ministry of Health and at the outbreak of the last war was based on the Town & Country Planning Act of 1932.

Under the 1932 Act, local government authorities responsible for implementing the provisions of the act, had few positive powers within the area they administered for controlling or guiding development and land use, and few local authorities took all the formal steps in the preparation and submission for approval of their planning schemes that in theory would give them effective control. The Act provided for the approval by Parliament of Town Planning schemes and once approved by Parliament as a statutory scheme any amendment or modification of the scheme involved a long and cumbersome procedure for Parliamentary sanction.

The necessary procedure in preparing and submitting a scheme,

and its rigidity when once approved, deterred all but a few local authorities from fully using the Act; the majority of them preferred to give planning consent under an Interim Development Order pending the coming into operation of a statutory scheme at an undetermined date. For extensive areas of the country, no planning consent to the development was required; few cities had a town planning scheme as a basis for giving consent to development, and even the grosser and more obvious mistakes in physical development were often permitted. Fear of the compensation involved in refusal easily outweighed the somewhat remote possibilities of collecting betterment charges when the positive planning powers of local authorities were so restricted.

The self-evident neglect of the physical development of the iron and coal producing areas of North East England, South Wales and Central Scotland, and the equally self-evident growth and expansion of London, led to the appointment in 1937 of a Royal Commission of enquiry into "The Distribution of the Industrial Population." It was its report, the Barlow Report, completed at the outbreak of the war, that drew attention to the failure of town planning legislation and government powers generally to deal with national and regional planning problems, particularly as regards the location of industry. All members of the Commission were agreed on the need for a new authority to deal with this aspect of planning. The form and powers of the proposed authority were, however, the subject of dissentient memoranda. Several members recommended the creation of a Government Department or Board responsible to a Minister with planning powers not only over the location of industry, but to have also the planning powers then exercised by the Minister of Health and Minister of Transport.

The Report was presented to Parliament in January 1940, when Government Departments were rapidly being expanded and changed to suit war conditions, and Lord Reith as Minister of a new Ministry of Works and Buildings took the report as a basis for his recommendation to the Government on Post War Reconstruction and Planning.

From June 1942, for a short period, the Ministry of Works took over the town planning responsibilities from the Ministry of Health

and was re-named the Ministry of Works and Planning. During this time the Ministry received two important reports of committees appointed by Lord Reith, when Minister of Works and Buildings; one, the Scott Report on "Land Utilization in Rural Areas," the other, the Uthwatt Report on "Compensation and Betterment" in respect of Public Control of Land Use.

The magnitude of the planning problems arising from air raid devastation of our cities, and the need for fresh planning legislation that would have regard to the findings of the Barlow, Scott and Uthwatt reports led the war-time coalition government to set up, in February 1943, a separate Ministry of Town and Country Planning, charged with the duty of "securing consistency and continuity in the framing and execution of a national policy with respect to the use and development of land thoughout England and Wales." Similar duties were given to the Secretary of State for Scotland, and town planning has continued to be the administrative responsibility of the Department of Health for Scotland.

The new Ministry's status *vis-a-vis* other government departments was undefined, and in spite of a widespread and general public enthusiasm for town planning to be a dominant factor in post-war reconstruction, it was left to the new Ministry to try to define its field of action when economic planning and much physical planning of the country was largely in the hands of other long established and powerful departments, such as the Board of Trade, Ministry of Labour, Ministry of Transport and Ministry of Agriculture. During the war there was in fact for a short time a Minister of Reconstruction, coordinating several government departments for both economic and physical reconstruction.

The Planning Ministry Gets to Work

The first act of the new Ministry of Town & Country Planning was to make all development of land subject to planning consent of a Local Planning Authority. The basic 1932 Act legislation remained unchanged. There was, however, a general and urgent desire to provide new planning legislation to assist blitzed cities to develop on better lines and to prevent a reversion to pre-war conditions of

congestion. But in spite of its introduction by the Coalition Government, the Town & Country Planning Act of 1944 had a difficult passage as a Bill. As it emerged, it gave local authorities new and wide powers of acquisition of land for many planning purposes, but its main provision was to facilitate the acquisition and redevelopment of war damaged areas in order to lay them out afresh and to avoid the difficulties which would otherwise arise in dealing with a multiplicity of owners.

Under the 1944 Act, nearly 400 acres of land in the "blitzed" towns have been designated and confirmed by order of the Minister as subject to compulsory purchase. Several other large areas are under consideration, and there will in the near future be few large areas of war-damaged land in the centers of our towns that will not be liable to compulsory acquisition by the local authority for the purpose of laying out afresh and for redevelopment as a whole.

The necessity to make the land subject to compulsory acquisition has had to be proved by public enquiry for each case, but local authorities were emboldened to undertake the new and heavy responsibilities of public ownership by the promise of substantial grants from Treasury funds towards the cost of acquisition and clearance of the land. In its original form, the system of grants proved unacceptable to local authorities. Recently the whole system has, however, been consolidated and extended for operation under the Town & Country Planning Act of 1947, and now provides varying grants for acquisition of land other than war-damaged land.

Early Advisory Plans

Actual acquisition and redevelopment has now followed quickly on the Minister's confirmation of a local authority designation of land, partly because the compulsory purchase of property within a designated area can be subject to further public enquiry as to the acquisition's being expedient but mainly because the economic crisis of the last eighteen months has led to a general restriction on capital investment by local authorities. The latter, coupled with restrictions on the release of men and building material for other than works of national priority, of which "blitzed" city reconstruction has not

ranked as one, accounts for the comparatively little actual physical redevelopment on land designated under the 1944 Act.

The war's devastation, and the promise of more extensive planning powers for local authorities than were contained in the 1932 Act stimulated many of them to produce advisory plans and reports indicating possible future development and redevelopment of the areas for which they, as planning authorities under the 1932 Act, were responsible. The Advisory Plans have been sometimes the work of planning consultants, sometimes the work of the authorities' own officers, and sometimes a work of collaboration by both. In the main, these advisory plans and schemes have served admirably in arousing public interest in and awareness of the possibilities in planning physical environment. But the conditions under which they were produced when there were high hopes of, but no certainty of, legislative or financial powers to carry out the schemes and the lack of adequately surveyed data as a basis for proposals, made nearly all of them no more than preliminary designs for the kind of Development Plans, now required under the new 1947 Act.

The better advisory plans have provided a rough framework on which to base interim planning decisions and have often led to further examination of particular aspects of physical planning by the Ministry of Town & Country Planning and other government departments, e.g., an expert committee examined and reported to the Ministry of Transport on the technical and operational aspects of the railway proposals in the "County of London Plan 1943."

The "Greater London Plan 1944," which was a logical extension of the "County of London Plan," recommended, as part of a policy for decentralization of inner London, the creation of a number of new satellite towns beyond a proposed and partly established green belt. As a result, the Minister set up a New Towns Committee to report on the practicability of such a recommendation not necessarily limited to London planning problems. Their report forms the basis of the New Towns Act of 1946, a short Act that passed quickly and smoothly through Parliament. It has enabled the Minister to designate 35,000 acres of land as sites for eight new towns and to appoint Development Corporations with exceptionally wide

powers to develop them, as social and physical entities for populations up to 60,000 people.

The 1944 Act, although it gave local authorities positive powers for planning and carrying out development, did not, however, resolve the vexed question of compensation and betterment arising on every application to a planning authority for consent to develop land. The Uthwatt Committee, which had examined this question closely, made one of its main recommendations "the vesting in the state of the rights of development lying outside the built-up areas on payment of fair compensation, such vesting to be secured by the imposition of a prohibition against development otherwise than with the consent of the state, accompanied by the grant of compulsory purchase powers of acquiring land itself when wanted for public purposes or approved private development."

New Act into Operation Last July

Such a recommendation or anything like it could not be carried out with Central Government and Local Government Planning Authorities as they were. The Labour Government presented a Bill that not only proposed a fundamental change in the rights of owners to develop land that in some respects went beyond Uthwatt Committee recommendations, but also introduced a new concept of town and country planning and a radical change in the kind and number of planning authorities. The Bill, despite its 120 clauses and 11 schedules, was put through Parliament rapidly and the resultant Town & Country Planning Act 1947 came into full operation on the first of July, 1948.

Under this Act a Central Land Board responsible to the Minister of Town & Country Planning will deal with all claims for compensation and collect all betterment charges resulting from the operation of the Act. A development charge, assessed and collected by the Central Land Board is, with few exceptions, to be levied on all changes of use of land or buildings. Any material change of use will require planning permission and the development charge is payable or secured before the change is made. Compensation payable for loss

of development value that would otherwise have accrued to land holders is to be from a Government fund of 300 million pounds. When present claims have been met, no more will be entertained and henceforth the value of the land will be its ascertained existing use value, and land may be acquired at existing use value for State or Local Government purposes.

In England and Wales, there were before July 1948, 1441 individual Planning Authorities with powers under the Acts of 1932, 1943, and 1944. The 1947 Act has limited the number to some 150 by limiting Local Planning Authorities to County Councils and County Borough Councils, there being few towns with less than 100,000 population having County Borough status.

The power of giving or withholding consent to development is now reinforced for Local Planning Authorities by powers of compulsory acquisition of land for planning purposes and the Authority can itself secure the carrying out of the desired development. Financial aid at varying rates is available from Government funds to assist the Local Authorities to acquire land and to lease it to developers and a Local Authority can itself carry out development with or without financial assistance from sponsoring Government Departments.

The third main provision of the 1947 Act sweeps away the conception of the Statutory Planning Scheme and in its stead places upon a Local Planning Authority the duty of submitting to the Minister within three years from the appointed day, that is, the first of July 1948, a Development Plan indicating not only the development envisaged by the Planning Authority in twenty years—or more for a few items of physical development—but also a program indicating when that development is likely to take place.

Survey Requirements

In preparing its Development Plan, which is subject to revision every five years, a Local Planning Authority must base its proposals on a comprehensive survey of the social, economic and physical conditions in its area.

The main survey requirements have been indicated in the Ministry's Circular No. 40, a document that shows not only the data a

Local Planning Authority should collect, but also the information that will be supplied to it from Central Government. Almost every major Government Department is committed to supplying data or information as to its own requirements and those of Public Boards or Statutory Bodies for which it has some responsibility, e.g., National Coal Board, British Electricity Authority, British Railways; the information will range from the Registrar General's population estimates to the Ministry of Transport's trunk road proposals, from the Board of Trade's policy on the distribution of industry and the Ministry of Labour's prospects of industrial employment to the Forestry Commission's afforestation proposals.

The collection and dissemination of such information is in itself a formidable planning task but the main task lies with the Local Planning Authority in integrating the information with its own survey data and from it producing realistic Development Plan Maps and Program Maps, even though those maps will show only broad and major planning proposals.

Presumptive rights to develop land in accordance with the zoning provision of the 1932 Act have disappeared and a less arbitrary but more searching assessment of the probable consequence of allowing or preventing development takes their place. It is a system that will no doubt lend itself to the typically English genius for compromise and the results are likely to be spectacularly successful. Nevertheless it should ensure all Development proposals being given full consideration whether they appear to be contrary to the planning intentions of the Planning Authority or not, and the firmness of a planning intention will be tested by the extent to which it consolidates public opinion as to what is the real purpose of town planning; it cannot rest on arbitrary decisions derived merely from a set of so-called planning principles.

The main tasks of the Ministry are the coordination of view of other Government Departments insofar as they affect land-use and physical planning, the reconciliation of those views with those of Local Government Planning Authorities; and the approval or disapproval of Local Planning Authorities' decisions as they affect the citizen and the developer.

The Minister does not, in fact, plan the country physically,

economically, or socially, except insofar as he approves or otherwise the planning proposals and decisions of Local Planning Authorities and influences the planning policies of other Government Departments.

All development, with a few exceptions of a minor character, now require planning consent. Appeal against a decision of a Local Planning Authority lies with the Minister. The Minister, after a hearing of parties or a public enquiry, confirms or rejects that decision, and his decision can be challenged only in the High Court of Justice.

Functioning of the Planning Ministry

Compared with other Ministries, the Ministry of Town & Country Planning is small. The total number of staff of all kinds, inclusive of both those at Headquarters and in the Regions, is little more than a thousand, and the severe limitations on manpower imposed on all Government Departments will require the staff to make exceptional efforts to cope adequately with the problems arising from the new legislation.

The first Minister of Town & Country Planning, Mr. W.S. Morrison, of the war-time Coalition Government, was succeeded in 1945 by the present Minister, Mr. Lewis Silkin, of the Labour Government. It is the Minister who transmits Government policy to his Ministry and gives direction to that policy. Although not a member of the Cabinet, the Minister is of Cabinet rank and home Government matters, including town planning, are usually dealt with at meetings convened by the Lord President of the Council. In the handling of parliamentary and political matters, the Minister is assisted by the politically appointed Parliamentary Secretary.

The administration of planning legislation and policy is the responsibility of the Civil Service staff headed by the Permanent Secretary. The organization of the Ministry has undergone many changes since it was set up in 1943, but at present it has five main divisions under the general direction of the Permanent Secretary and the Deputy Secretary. Four of the divisions, for which there are Under Secretaries, have responsibility broadly in accordance with

matters arising under (i) Finance, (ii) Local Planning Authorities, (iii) Legislation and general matters, (iv) New Towns, and a fifth division under a Director of Technical Services covers the work of the Technical, Research and Inspectorate Staff.

In order to facilitate and maintain contact with Local Planning Authorities and with the Regional organizations of other Government Departments, the Ministry has Regional Offices in Newcastle-on-Tyne, Leeds, Nottingham, Cambridge, London, Reading, Bristol, Cardiff, Birmingham, Manchester and Tunbridge Wells, for the eleven divisions of England and Wales corresponding to the Civil Defence Regions set up during the war. At each of the Regional Offices the Ministry convenes regular meetings of a Regional Physical Planning Committee with representatives from the Ministry of Health, Ministry of Transport, Ministry of Agriculture & Fisheries, Ministry of Works, Ministry of Supply, Air Ministry and Ministry of Fuel & Power; other Government Departments are represented as occasion demands.

The Regional Physical Planning Committees keep under review as a matter of long term policy the fundamental planning problems of the Region as they affect the use of land and the settlement of population and make recommendations to Headquarters from time to time. They also deal with particular development proposals of major importance (excluding the industrial schemes dealt with by the Distribution of Industry panel) which affect the land use of different Departments and require consultation and decision regionally or at Headquarters. It has thus been the role of the Ministry of Town & Country Planning to demonstrate to other Government Departments the probable consequences of the development of land and whilst it is not an arbiter on conflicting claims of Departments, they are assured of careful consideration and appeal can be made if necessary to the Lord President's Council for settlement.

Local Planning authorities have, under the 1947 Act, been considerably reduced in number and the delegation of planning responsibilities from the larger to smaller units of Local Government for which the Act provides has not been accomplished without difficulty. The smaller units have been loath to surrender their planning

powers and have done so only on the assurance of the Minister that they will be fully and properly consulted by the larger authorities during the preparation of a Development Plan.

The tradition of English Local Government is against the regions as a unit of Government and whilst the 1947 Act provides for the setting up of Joint Planning Boards as Planning Authorities, such plans and reports as have been made for areas covering several Local Planning Authorities and sponsored by the Minister have been advisory in character, e.g., Greater London Plan, Merseyside Plan, West Cumberland Plan, North-East Development Area Plan, West Midlands Plan and the South Wales Outline Plan.

The change in the planning system has not been made easier by the unevenness of strength of Local Planning Authorities before the 1947 Act came into force. Moreover, the lack of adequately trained and experienced staff to fill the posts advertised by the New Local Planning Authorities to enable them to carry out their new duties, is a matter of some concern to the Ministry. Recently the Minister appointed a committee to examine and report on "The Qualifications of Planners" and in enquiring into the facilities for the training of planners the committee is charged with taking account and reporting on the scope of Town & Country Planning and what kind of planners are required for the new system of planning brought about by the Act.

The emphasis in the new Act is no longer on the negative aspects of town planning, it is optimistically positive. Development is to be encouraged to the fullest extent of the economic position of the country and the powers for positive planning that have been given to Local Planning Authorities and the Development Corporations of the New Towns will mean a degree of cooperation of Local Government with Central Government not hitherto attempted if those powers are to be used successfully.

The use of land is both a critical and a vital factor in the economy of such a small and valuable island as Great Britain and whilst the primary interest of the Ministry of Town & Country Planning is the use of land, the Ministry will be the trustee for the physical environment of a people that is becoming increasingly aware of how planning decisions can affect their daily lives in a multitude of ways.

Road Signs, Signals, and Markings: What Do They Mean?

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THE paraphrase, "They also serve, who only irritate" might well be used as a reason for this article.

In the development of uniform signs, signals, and markings for streets and highways, considerable progress has been made in the last twenty years. But obviously, still more is needed. A cross-country tour reveals differences, peculiarities, and deficiencies; sometimes amusing, sometimes confusing. On a recent trip through thirty states I noted instances of non-uniform practices and other questionable aspects of traffic-control devices.

"—perhaps you're to stop twice as fast."

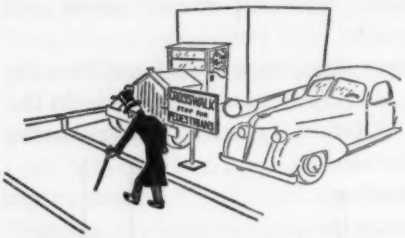
Several times I saw two Stop-signs mounted on the same post. If two Stop-signs mean STOP, what does one Stop-sign mean? Frequently I found warnings of a "dangerous" condition. Typical was "Dangerous Intersection Ahead" or "Danger—Hill and Curve Ahead." Why, if the situation is known to be bad, is it not corrected?

In one small town, attached to the traffic signals in the central business district, I confronted signs directing me to "Turn Left on White Signal." Not until I had driven through several intersections, perhaps violating the regulation repeatedly, did I realize that the white signal replaced the normal amber light, and that motorists wishing to turn left were supposed to wait out the

green period in a lane near the center of the street and then complete the turn during the brief white signal.

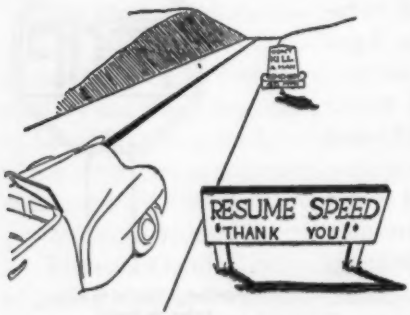
Pretty Hard on a Stranger

Approaching a complicated signalized intersection in one city, I encountered this invitation: "Turn Here Any Time." So, in relatively fast traffic, I made the split-second decision as to the point at which an uncontrolled turn could be made, and estimated the protection the sign would afford me—difficult decisions for a stranger.



"—never have so many owed so much to so few."

As a motorist, I was annoyed in some areas by the widespread use of crosswalk signs based on poor practice and unfair right-of-way privileges for pedestrians. Typical wordings were "Stop When Pedestrians Are In Cross-walk" . . . "Cross-walk—Stop If Occupied" . . . "Cross-walk—Stop For Pedestrian." Time after time I saw lone pedestrians, sauntering across the street, delay heavy traffic in each direction. Even though pedestrians in, or approaching, cross-walks have the right-of-way, the practice of advertising the fact with signs invites abuse and unnecessary hazard. Overconfident pedestrians might not use the precaution that would otherwise be natural for persons afoot. Off-hand, it would seem that only casual violation by motorists at such places might result tragically, whereas similar violation would give no trouble if pedestrians had assumed their share of the responsibility.

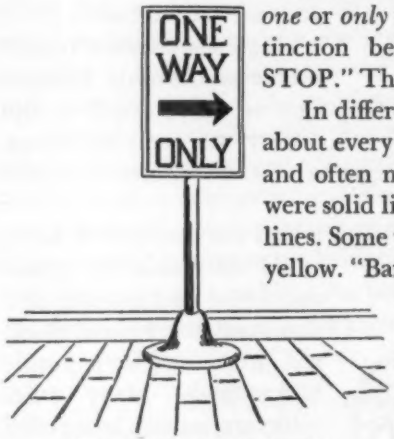


"—courtesy and caution."

I don't know whether subtle warning or courtesy was intended by the sign, "Remember 45-Mile Speed." On the other hand, I suppose everyone would interpret as a courteous gesture the sign inviting motorists to "Resume Speed—Thank You." But at what speed does one travel when a sign reads, "Restricted Zone for 16 Miles"?

In two small towns, blaring signs along Main Street announced "Parallel Parking!" But there were no pavement markings or guides to parking stalls. Consequently the parking I saw had no parallel: it was completely unregulated and non-uniform.

Conservation of sign material may have been intended by the use of this one—"Slow Many Curves." And new roadway terminology seems to have been developed by "Slow—Switchbacks Ahead."



"—a tendency to redundancy?"

In the message "One-Way Only," either *one* or *only* is superfluous. It is like the distinction between "STOP" and "FULL STOP." The sign usually has an arrow, too.

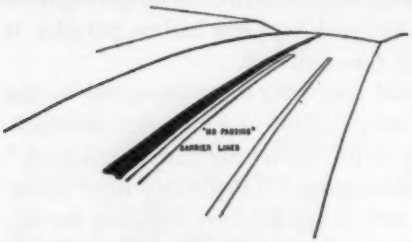
In different parts of the country I found about every conceivable type of center-line, and often no markings for passing. There were solid lines, dashed lines, no lines, wide lines. Some were white, some, black; others, yellow. "Barrier" lines to designate sections of roadway where passing is prohibited were sometimes solid, at other times dashed; the same color, or different color from that of the center line. Usually one finds them immediately adjacent to the center line, but in a few places the barrier or no-passing lines are several feet to the right of the center, approximately in the middle of the roadway line one is traveling. In some cases, at points of restricted sight-distance, the dashed center line becomes a solid line. At present the confusion and lack of uniformity in roadway markings leaves the motorist wondering what to look for and where.

A common word in our language is Stop. It is subject to one interpretation; it has but one meaning, clearly understood by any child. Yet it is many times modified on highway signs. There are the

stops, the *absolute stops,* the *full stops,* the *full-stop streets,* and others.

Sizes, Shapes, and Colors!

Messages aren't the only queer factors in signs. Extremes in sizes, shapes, and colors abound. Sizes appear to vary in some rough ratio to the degree of hazard. At some points conditions must be serious, because signs have taken on bill-board proportions. Of others, the conditions can't be too important because signs are so small they are hard to find.



"—sometimes here, sometimes there."

Sign shapes show considerable uniformity. Octagon Speed-limit markers and round Stop-signs are fairly standard. But some jurisdictions expect *shapes* to convey too many meanings. Route markers and destination signs have been conceived in about every possible shape.

Colors used on official signs suggest that the spectrum is being taxed. As should be, yellow and white backgrounds predominate. But I found black, red, green, and even purple backgrounds. Many other colors are, indeed, being tried in an effort to reflectorize route markers.

"—getting stop-happy!"

Even sign-*location* bears mention. At one time, I would find a sign immediately off the improved surface of the roadway; at another it would be several feet beyond a ditch-line. Sometimes I found signs a few feet above the pavement; at others ten feet or more. At one place, I saw a sign on the right-hand shouder; at a similar location a short distance ahead, the sign was suspended over the roadway. At still another place, it was marked on the pavement.

Dozens of other examples and situations would show we have not achieved full uniformity in traffic control devices. In the field of route markers and destination signs alone, deviations are noted in practically every state. Within cities differences are especially pronounced. Signals are found at every conceivable location. Illumination and reflectorization of signs and markings also vary widely. As a rule, small towns show the widest variations. They make many of their own signs and usually give them some individualist touch.

Signs Are for Improvement

Signs are intended to eliminate confusion. Those described *cause* confusion. Most of the non-uniform devices can somehow be understood. But wouldn't standard signs, signals and markings be understood more quickly and by *everyone?* It is difficult for the average motorist to sense immediately the full meaning and enforcement policy behind many of the novel devices he sees.

I certainly recognize that in every instance a new conception of road sign, a different type of marking, or special signal-installation has been aimed at improving traffic conditions and at reducing accidents. In some cases, non-standard signs may have been necessary to fit an unusual condition inadequately covered by usual devices. The problem is always to achieve the purpose in the most efficient way—for the greatest number of the traveling public.

Much Improvement in Recent Years

Despite variations, a marked degree of uniformity has been achieved. The nation has an encouraging number of generally adequate signs, signals, and markings. Compared with twenty to twenty-five years ago, we have a fine system. Route markers and destination signs, for example, make it possible to travel to almost any desired locality without losing your way.

Maybe you don't always take the best route, but the destination can be reached by "following the signs." Without the signs the way would be difficult as one crosses congested cities with confusing street patterns, or as one takes short cuts over lightly traveled roads in sparsely settled areas, or as night-travel restricts visibility and con-

fuses the sense of direction. Development of numbered routes comprising the federal-aid highway system and the state highway systems has taken most of the guessing and questions out of automobile trips.

In many states even the secondary routes and county roads have been numbered, and destination signs have been provided. The average motorist, given a road map and blessed with only a fair sense of direction, can find his way around the country without confusion. He always has a fairly complete understanding of roadway and traffic conditions based on the information conveyed through traffic control devices.

The negative factors begin to develop, however, as one travels beyond his daily range of activity. He begins to find it necessary to decipher new signs and markings. Even signals. Sometimes the task is complicated by having the same devices used for entirely different purposes and under varied circumstances.

A Manual on Uniform Traffic Control Devices

Major credit for achievement in developing an adequate and uniform system of highway markings and control devices must go to those responsible for the Manual on Uniform Traffic Control Devices. The first edition was circulated to the states about 1930, largely through efforts of the American Engineering Council and the National Conference on Street and Highway Safety, the U.S. Public Roads Administration, the American Association of State Highway Officials, and the Institute of Traffic Engineers.

A new edition[1] has been prepared and is now being given widespread distribution. It deals with phases of traffic control not previously covered and represents the best thinking and experiences available to the Joint Committee. Improvements cover design and erection standards as well as the application of signs, signals, markings and traffic islands. Undoubtedly the Manual will continue to have a profound effect on the practices of state and local agencies. It will be more widely sought and used than previous editions because

[1] Manual on Uniform Traffic Control Devices for Street and Highways, Public Roads Administration, U.S. Govt. Printing Office, Washington 25, D.C. $.50.

it is prepared and illustrated so as to make it more "usable," and because traffic conditions and public attitudes demand improvements, modernizations, and finally the most effective devices possible.

While the new sign manual fills some of the gaps, and will undoubtedly develop improved controls, many questions remain to be answered, and many contributions are needed before traffic control devices can be designed and applied entirely in keeping with traffic demands.

Research and Study Needed

Agreed that the intent behind each of the unusual devices is sincere, it is still difficult to explain the basic reasoning for many of them. Some obviously reflect the personalities of the persons responsible for them. Some result from sales efforts of manufacturers and agents. Others show nothing more than a personal desire on someone's part to "be different." All could show the displeasure of a public official or a public body with existing standards. In the final analysis, deviations provide clear and adequate evidence that more thought, study and research must be given to the improvement of present control devices.

At the same time, it must be recognized that there is a limit to which deviations, novelty and non-standard practices will be tolerated or can be allowed. We have come a long way on the improvement of road signs and signals. We still have a long way to go before all conditions are adequately met and complete uniformity is achieved.

Providing safe and expeditious travel for almost forty million motor vehicles is not a simple matter. Careful and continuing study is required. State and local officials must realize the magnitude of interstate travel, complexities developed by heavy volumes and high speeds, and the importance of judicial designs which go hand-in-hand with the use of traffic control devices.

All traffic officials should take part in research on devices. Devices should be studied everywhere under all the different physical and traffic conditions available. There is no better proving ground than the nation's highways that carry traffic of highly variable volumes and characteristics. In spite of opportunities afforded for study on this network of streets and highways, some aspects of control devices

can best be developed and measured in technical laboratories and through rigidly controlled studies.

It is essential, therefore, that federal agencies, universities, and manufacturers cooperate with local groups in seeking appropriate and adequate traffic control devices. Studies must cover not only the design details, but also the applications and operations practices. These are as important to uniformity as the devices themselves.

It is not enough that research and studies be conducted. Findings and experiences must be published and disseminated so that they can be reviewed, criticized and, if good, adopted throughout the country. It is fortunate that a leadership has been established. The Joint Committee on Uniform Traffic Control Devices can be looked to for coordination of activities that stem from all investigations, regardless of the level at which they are undertaken.

More State Control

Another way in which some of the undesirable signing and marking practices can be prevented is through extension of state controls over the practices of cities and local groups. It has long been recommended in the Uniform Motor Vehicle Code[2] that:

"The State Highway Commission shall adopt a manual and specifications for a uniform system of traffic-control devices consistent with the provisions of this act for use upon highways within this State. Such uniform system shall correlate with and so far as possible conform to the system then current as approved by the American Association of State Highway Officials.....

"... Local authorities in their respective jurisdictions shall place and maintain such traffic-control devices upon highways under their jurisdiction as they may deem necessary to indicate and to carry out the provisions of this act or local traffic ordinance or to regulate, warn, or guide traffic. *All such traffic-control devices hereafter erected shall conform to the State manual and specifications.*"

Adoption of such regulations by the state legislatures and their enforcement will do much to bring about uniformity within the

[2] Act V, *Uniform Act Regulating Traffic on Highways*, Public Roads Administration, U.S. Government Printing Office, Washington 25, D.C., 1945.

states. The over-all job will then be simplified to the extent of getting the states to agree. Such agreement will develop if a requirement is adopted that the state Manual conform with the latest Manual approved by the American Association of State Highway Officials.

Traffic control devices constitute only one matter affecting motor vehicle operations that must be made uniform and which will require increased state responsibilities if uniformity is to be accomplished within the foreseeable future. There are state rights, community rights, and individual rights, but limits must be established within which they are applied to traffic control devices.

Complete uniformity may never be achieved. For that matter, complete uniformity may never be desirable, because it would tend to retard development. But when the job of informing and regulating motorists and pedestrians can be adequately accomplished with uniform control devices, non-uniform devices and practices should be avoided.

Experimentation and new ideas are essential to progress, but they should not be used as the basis for casting aside our uniform standards.

Psychotechnology in Traffic Studies

T. W. FORBES

Dr. Forbes is Chairman and Associate Professor of Psychology at the University of Hawaii. During the war, he was research associate on war research projects in sound, gunnery and aviation at Stevens Institute of Technology, at the University of Pennsylvania and Harvard Psycho-Acoustic Laboratory. Previously he was Assistant Professor of Transportation at the Yale Traffic Bureau; Research Associate and Fellow, Harvard Traffic Bureau; Lecturer in Psychology at Columbia University and Research Psychologist at New York Psychiatric Institute, and Instructor in Psychology at Ohio State University. At Ohio State, his doctoral research in Applied Psychology included a study of estimation of speed on the highway and the invention of the Miniature Highway Driver Test. He is an affiliate member of the Institute of Traffic Engineers and a Fellow of the Industrial Psychology Section, American Psychological Association.

To trained psychologists, psychological problems must be approached with objective methods of observation and measurement, proper sampling and control, and mathematical analysis. The qualified psychotechnologist applies to practical problems of industry or traffic the methods of physiological psychology, experimental psychology, testing techniques, and psychological statistics.

Psychology means collecting facts of mental states and processes by observation or experiment, classifying and analyzing the knowledge so obtained and interpreting the relationships on the basis of scientific principle. Psychotechnology means the application of methods and knowledge of psychology to solve problems in practical fields.

The first Conference on Highway Safety in 1924 recognized the importance of psychological problems in traffic and set up at Ohio State University the first large-scale study of motor vehicle driving in the country. In spite of subsequent strides since that time in the automotive and traffic field, and in spite of improvement in the national safety record, psychological problems are still of major importance. We still find that from 70 to 80 per cent of street and highway accidents are attributable to human error or limitation.[1,2]

This means that in spite of the great advances in the mechanical perfection of the vehicle and in the design of highways, the human factor is still the major factor in the traffic safety problem.

Types of Safety Problems

Traffic safety problems that call for psychotechnological approach may be analyzed in four main categories:

1. What driver and pedestrian characteristics are primary causes of accidents?
   (a) What skill and lack of skill, habits, carelessness, fatigue, attitudes, etc. are involved? (b) Are these characteristics fixed in the individual, or do they change with the situation? (c) Can they be altered by training?
2. Are there certain "accident-prone" individuals whose characteristics make them especially liable to accident and who are not retrainable?
   (a) If so, what proportion of the safety problem do they represent? (b) How detected? (c) How treated? (d) What of the public?
3. What are the best methods of training drivers?
   (a) Safest and best driving techniques? (b) Teaching methods most effective?
4. What methods of safety education are of greatest effect?

Problems Relating to Broader Phases of Traffic

In the broader phases of planning traffic facilities, developing highway designs, devices for traffic control and the relation of traffic to economics, three types of problems are basically psychotechnological:

1. What psychophysiological limitations of the average driver must be given due consideration in the interest of both safety

and efficiency in new facilities and designs: What are the practical limitations of:

(a) speed of reaction, (b) speed and acuity of vision, (c) reading time, (d) time required for making choices and judgments, (e) accuracy of judgments required of the driver?

2. How can the normal reaction of the majority of people to new highway designs and to new signs and control devices be predicted?

(a) How do curvature, superelevation and speed affect the driver's reaction? (b) How does he estimate speed, and (c) How are the components of sign and signal design related to effective response of the driver?

3. What are the basic needs and desires that traffic plans must satisfy?

(a) Where do drivers want to go, (b) when, and (c) how much will they pay for greater convenience and for a saving of time? (d) how is parking demand related to such factors as walking distance, loading convenience and the driver's estimate of how close he can probably park?

The types of problems suggested are not intended to represent a complete coverage of the field, but merely to indicate to some extent the phases of the traffic problem the psychotechnologist may attack to advantage.

Contributions Already Made

Anyone familiar with the traffic field knows that answers (and good answers) to some of the previously cited questions have been obtained from studies by engineers and traffic analysts who were not specially trained in psychotechnology. Thus Cherniak[3] showed a definite relationship between time saved, convenience factors and the amount motorists would pay to cross the Hudson River bridges. Lynch[4] has reported the development for Public Roads Administration of an origin-and-destination-survey technique using geographical sampling and an interview technique similar to that de-

veloped for market analysis surveys. Carmichael[5] has made some valuable suggestions on driving technique and safety motivation based on observation of proving ground drivers over a considerable period of time. This mentions a few instances; there are many others.

Results of authentic studies of a psychotechnological type may be indicated as follows:

1. *Comparison of Accident Repeaters and "Unselected" "Accident Free" Drivers.* Numerous studies of reaction time, motor coordination and skill, speed estimation, visual abilities, intelligence and information from interviews were carried out between 1928 and 1941 by Weiss, Lauer, Forbes,[6] De Silva,[7] Johnson, Cobb, and others at Ohio State, Iowa State, the Harvard Traffic Bureau and under the joint auspices of Iowa State, Harvard and the Highway Research Board. And very recently a similar study has been reported by the staff of the New York University Center for Safety Education.[8]

In general, these studies show much the same results; that is, that accident-repeaters as a group show a slight inferiority on most of the skills and characteristics measured. Correlations between test scores and accident records were too low, however, to allow use of the test scores for prediction or selection of high accident individuals.

2. *Relation of Medical Examination Data and Personal History Data to Accident Experience.* Such data were obtained in the joint Highway Board study and also in a study of 500 Transit operators by Kraft and Forbes for the American Transit Association.[9] Again consistently low correlations were found with accident records corrected for mileage, peak traffic and seasonal variations of exposure to possible accident.

These results and those of previous studies were interpreted as indicating that so many of the skills, abilities and other characteristics (such as attention) may play a part in causing accidents that no one factor correlates highly. Furthermore, it is probable that a combination of lapses and deficiencies must occur on the part of several drivers simultaneously with the occurrence of a critical traffic situation.

Interview case histories obtained in connection with the Harvard Traffic Bureau Driver Test Clinic program[7] also yield evidence of this.

3. *Studies of "Accident-Proneness."* Analysis of the accident records of drivers for a period of years has consistently shown that a small group of drivers has a relatively large percentage of the total accidents. This has given rise to the idea that certain individuals are especially liable to accident due to some inherent characteristics and that they are not retrainable.

The largest and most careful such analysis conducted by Johnson for the Highway Research Board[10] studied the records of about 25,000 Connecticut drivers through the co-operation of State Officials and found that 3.9 per cent of these drivers had about 36 per cent of the accidents during a six year period. This finding was advanced as evidence of accident-proneness.

The author[11] showed that if the same data were analyzed into the first half against the second half of the six year period, the majority of the high accident drivers were different people. This would seem to indicate that all but a very small percentage can learn to drive safely.

4. *Educational Effect of "Driver Clinics."* Follow-up studies of accident records for a year after "Driver Test Clinics" conducted in several New England cities were carried out by the Harvard Traffic Bureau.[12] Results indicated greater improvement than among repeaters who did not attend, thus indicating the re-educational effect of the "Clinics."

5. *Factors in Effectiveness of Highway Sign Design.* Lauer has conducted numerous studies of letter proportion, stroke width and spacing for optimum effectiveness, and Forbes and Holmes[13] showed that legibility distances could be determined for standard alphabet letters and related to letter height. The author demonstrated methods of analyzing sign efficiency further into legibility, glance legibility and attention values, while calculation of proper letter size and sign placement on the highway for given design speeds was treated by Mitchell and Forbes.[14]

6. *Time Required for Driver Perception, Judgment and Reaction.* Data from the various driver test studies together with measurements made on the highway with the aid of students at the Yale Bureau were presented to show that driver reaction in a simple emergency situation averages from 0.5 to 0.7 seconds, but may be as

long as 2.8 to 3.25 seconds when a complex judgment must be made by the driver on the road.[15]

7. *Distance Required for Passing.* Matson and the author showed[16] that observations of actual passing by the driving public could be made by means of a simple photographic and timing technique. By this method passing distances were analyzed by types of pass, type of terrain (and expectation of passing opportunity) and presented in relation to speed of the passed vehicle. Distances required by 80 per cent of the drivers were suggested as the best basis for design considerations. Larger-scale studies on this subject with elaborate stationary recording equipment have since been carried out by the Public Roads Administration.

8. *Estimation of Speed.* At Ohio State[17] it was found that estimates of speed by student subjects were highly inaccurate and corroboration of this was found in connection with the Yale studies.[18]

9. *Analysis of Channelization in Terms of Limits of Driver Abilities.* It was pointed out that channelization remedies a problem which is basically a psychological one. The success of good channelization design then depends on reducing the number and character of the choices and judgments necessary on the part of the driver to allow operation within the shortest limits of driver perception, judgment and reaction time.[19]

Many other studies involving psychological problems in highway traffic have been carried out by psychotechnologists, but the above examples will perhaps give an idea of the kind of contribution which has been and can be made. A more complete discussion of these and other studies is given elsewhere.[20]

Need for Future Psychotechnological Work

As the reader will see, a number of problems suggested have not been fully solved. Furthermore, the psychological problems in traffic do not always stay solved because in the attempt to eliminate one problem by new developments in vehicles and highways a new problem often is introduced.

A facetious example that makes the point is a cartoon showing a baffled motorist talking to a traffic officer at the bottom of an inter-

change ramp on an express highway. "Officer," he is saying "I've been around this thing six times now. How do I get out of here?"

A continuing, organized attack on the psychological phases of traffic should be carried on. It is suggested that trained and qualified psychotechnologists should be connected with programs in each of the three E's (engineering, education, enforcement). Certain studies have, in the opinion of the writer, overlooked psychological factors that should have been controlled. On the other hand, a psychologist on a university staff cannot ordinarily handle studies of traffic problems as well when working alone as he can in co-operation with traffic organization or trained traffic personnel. This is because of many other duties required of him, and because it is more difficult to carry on the work under road conditions. In certain of the psychological functions involved, indoor conditions do not give the same results as those under outdoor, highway conditions.

It is suggested, therefore, that there be a continuing attack on all the problems of highway traffic, using the psychotechnological approach wherever possible and carried on wherever qualified personnel are available and interested. It is also suggested that whenever possible the psychotechnologist and the traffic engineer or other traffic specialist should work together to obtain the answers and to apply them to the practical problems of increasing the safety and efficiency of motor vehicle traffic and operation.

REFERENCES

1. Baldwin, D. M. Traffic on the Turnpike. Public Safety, 1946, 30, No. 6, pp. 6–7.
2. Anon. Driver Failures Cause Most North Carolina Accidents. Public Safety, 1948, 34, No. 6, p. 19. Brief note on results of a study by R. A. Burch of North Carolina State Highway and Public Works Commission.
3. Cherniak, Nathan. Measuring the Potential Traffic of a Proposed Vehicular Crossing. Paper presented at Yale Bureau for Street Traffic Research. May 1939.
4. Lynch, John T. Origin and Destination Surveys in Urban Areas. Proc. Hway Resch. Bd. 1944, 24, 239–254.
5. Carmichael, T. J. This Business of Safe Driving. Traffic Quarterly, 1948, II, No. 4, 340–347.

6. Weiss, A. P.: Lauer, A. R. *et. al.* Psychological Principles of Automotive Driving. Ohio State Univ., Contrib. in Psychol., 1931, No. 11, pp. 165.

7. De Silva, H. R. and Forbes, T. W. Driver Testing Results. Harvard Traffic Bureau and W.P.A. of Massachusetts, WPA, Boston, 1937, pp. 98.

8. Center for Safety Education. New York University. Personal Characteristics of Traffic Accident Repeaters. Eno Foundation for Highway Traffic Control, 1948, pp. 64.

9. Kraft, Merwyn A. and Forbes, T. W. Evaluating the Influences of Personal Characteristics on the Traffic Accident Experience of Transit Operators. Proc. Hway Resch. Bd., 1944, 24, pp. 278–291.

10. Secretary of Agriculture. Motor Vehicle Traffic Conditions in the United States. Part 6. The Accident Prone Driver. House Document, 1938, No. 462, Part 6, Govt. Printg. Off. Washington, D. C.

11. Forbes, T. W. The Normal Automobile Driver as a Traffic Problem. Jour. Genl. Psychol. 1939, 20, 471–474.

12. Forbes, T. W. Age-Performance Relationships Among Accident Repeater Automobile Drivers. Journ. Consult. Psychol. 1938, 2, 134–148.

13. Forbes, T. W. and Holmes, R. S. Legibility Distances of Highway Destination Signs. Proc. Hway. Resch. Bd. 1939, 19, 321–335.

14. Mitchell, A. and Forbes, T. W. Design of Sign Letter Sizes. Proc. Amer. Soc. Civil Engrs. 1942, 68, 95–104.

15. Forbes, T. W. Methods of Measuring Judgment and Perception Time on the Highway. Proc. Hway. Resch. Bd. 1939, 19, 218–231.

16. Matson, T. M. and Forbes, T. W. Overtaking and Passing Requirements as Determined from a Moving Vehicle. Proc. Hway. Resch. Bd. 1938, 18, Part I, 100–112.

17. The author. Measuring Drivers' Reactions. Personnel Jour. 1932, 11, 111–119.

18. The author and Matson, T. M. Driver Judgments in Passing on the Highway, Jour. Psychol. 1939, 8, 3–11.

19. The author, Discussion of "Channelization of Motor Traffic," by Guy Kelcey. Proc. Amer. Soc. Civil Engrs. 1949, 66, 1009–1014.

20. The author, Chapter on Psychology in Highway Traffic in a book on Applied Psychology, edited by Fryer, D. and Henry, E. R. Rinehart Co., N.Y. In Press.

Houston's Urban Expressways

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THE general plan for expressways in Houston, Texas, consists of radial routes extending from the vicinity of the central business district to connections with the principal highways leading to other cities. (See vicinity map)

The expressways serve the triple purpose of carrying the external traffic directly into or through the city, moving the intra-city traffic between the several sections of the city and of moving the extremely heavy volumes of traffic into the central business section and return.

The first of these movements is relatively light. A thorough survey made by the State Highway Planning Division showed that less than 6 percent of the external traffic passed through the city without stopping. Only about 10 percent of the traffic originating within the city has a destination beyond the suburban areas. Since the expressway system is connected with all of the principal highways and is an interconnected system it affords a better facility for external traffic crossing the city than is usually provided by circuitous by-pass routes.

The traffic moving from one section of the city to another is provided with reasonably direct routes that do not pass through the heavily congested streets of the central business area. All routes pass only a short distance away, making it convenient to turn into the downtown area to shop or transact business and continue on to another section of the city. The greatest traffic movement is that between the urban and suburban areas and the central business section.

The geometric design of the freeway portion of the expressway is relatively simple after the interchanges have been located and

Typical Railroad Overpass. Note That Frontage Roads Do Not Cross Railroad, Completely Eliminating Accident Factor

their required capacities determined. It is not too difficult to design adequate interchanges spaced at approximately half-mile intervals in the outlying areas to provide facilities for the collection and dispersal of a few thousand vehicles at each interchange. Generally, as the central area is approached the design of the interchanges becomes more complex because of the larger volumes of traffic on the expressway and on the transverse arteries. The interchanges usually must be more closely spaced and the number of freeway lanes increased.

When the many thousand vehicles arrive in the congested downtown area, the problem of dispersal and of collection becomes much more difficult. The expressway traffic must enter into or cross the streams of traffic flowing on other arterial routes or merge into the city street pattern.

The Houston plan for the handling of this large volume comprised of many streams of traffic flowing in all directions, differs from that of most cities. Instead of designing a more complex facility for the purpose a plan of great simplicity has been used.

U. S. 75 expressway enters the city from Galveston at the southeast city limit and continues in a northwesterly direction to the vicinity of the central business district. This section is a four-lane expressway in the suburbs and is increased to a six-lane facility where the traffic volume requires the additional capacity. There are eleven interchanges within the city limits on this section. These interchanges vary in design and capacity in accordance with traffic requirement. Frontage or service roads are provided throughout except at three of the four railroad crossings.

A few blocks southeast of the central business district a transition has been constructed to provide for the merging of the freeways and service roads into four east-west city streets. Near the southwest corner of the central area a similar transition has been designed to provide for connecting the four streets into the expressway which turns north at this point and continues generally northerly to a connection with the existing Highway U. S. 75 to Dallas.

This "Four Street System" and the eighteen transverse north-south streets with the traffic control signal system that has been installed constitute a master interchange of great magnitude with a

capacity for the dispersal and collection of a very large volume of traffic. Each street is a controlled thoroughfare and each of the intersections is an interchange unit. The entire 72 intersections are controlled by an interconnected synchronously operated traffic control signal system, believed to be the largest and most complete that has been installed and put into operation at one time.

The eighteen north-south streets carry almost all of the traffic between the principal business district and the large residential areas and community centers in the south and southwest sections of the city. The expressway from the southeast brings the traffic from large residential sections and in addition serves the heavy industrial areas in the eastern part of the city around the Houston harbor and along the ship channel.

This traffic is dispersed not only northward into the business district but southward or carried on westward past the center of the city. When other expressways included in the overall plan are in operation part of this traffic will be delivered to them to be moved to other sections of the city or on out to highways leading out of the city. Provision has been made for future elevated freeways to carry the traffic destined to the north and west through the "Four Street System" if or when conditions justify the installation. The manner in which this interchange is functioning at present indicates that the additional facility will not be needed for many years.

All four streets are being operated as express arteries but with greater restrictions on the central pair. Truck and bus traffic is prohibited from using them but is permitted to use the outer streets. The north pair are operated for westbound and the south pair for eastbound traffic. The north-south streets are being operated, generally, in the following directional sequence in groups of three: first, one-way, northbound; second, one-way, southbound; third, two-way.

This directional sequence for these streets is continued northward into and through the central business area and southward for a considerable distance. All of the east-west streets passing through the downtown area are being operated in a similar manner. All of the four streets have a minimum pavement width of 52 feet, provid-

ing three 12-foot travel-lanes with an 8-foot parking lane on each side. Parking, however, is prohibited during the peak traffic period.

Our plan provides for each three-lane freeway to transition into two streets of three travel lanes each, or six lanes, as the traffic flows into the signalized express street pattern and for outbound traffic to converge into the freeway in a comparable manner. The modern elaborate traffic control signal system with its triple dial secondary controllers, all synchronously operated through a master controller, permits a flow of traffic through this interchange far in excess of that considered possible a few years ago.

Four sections are provided on each signal head for each direction of approaching traffic. Directional arrows are used for all permissible turning movements. The controllers, equipped with timing devices, provide for the adjustment of the time intervals to favor the heavier traffic movements which vary both in direction and density throughout the day and night. This feature is particularly important as the north-south movement is heavier on the western half of the interchange and the east-west movement is greater over the eastern half.

A large portion of the traffic from the south and east leaves the express streets before reaching the heavily congested north-south arteries leading directly into the central business section. Provision is made in our plan for much of the volume with an origin or a destination west, north or east of the central area to be collected and dispersed through other similar "Express Street Systems".

Volume counts made recently show a total movement in excess of 200,000 vehicles per day is being handled through the "Four Street System" interchange. Speed delay studies show an average waiting time loss of not more than thirty seconds for the east-west movement and no appreciable delay for the north-south movement unless the motorist is stopped by a red light before entering the system. The signal controls are adjusted to insure minimum delay for the north-south movement as it is about four times as great as the east-west movement.

The average speed through the interchange is about 25 miles an hour. The legal speed limit is set at 35 m.p.h. and except during

periods of peak traffic flow it is practical and safe to drive at that speed. In the eastern two-thirds of the interchange, the time-interval sequence or band is set for 28 m.p.h. using the double alternate or "ripple" system, so that a motorist in the middle of the time-band can "make" every light at that speed. If a motorist is late in the cycle he can speed up and stay within the rippling green light band.

The four east-west express streets were designed to carry a total volume of 70,000 vehicles per day. The capacity can be increased to equal the capacity of the connecting expressways by elimination of parking and adjustment of signal control. The eighteen north-south streets have a potential capacity in excess of 300,000 vehicles per day. Actual counts during the past few days showed a total volume of 113,000 vehicles moving north and south on seven adjacent streets.

It is believed that a complex interchange, designed to load and unload a huge volume of traffic through a very few arteries of the city street pattern would not function as well as the type now in operation in Houston.

The pattern of the Four Street System interchange will not be followed exactly for collection and dispersal of traffic from the other expressways as they approach the central area but a comparable plan will be used. The design will necessarily be affected by the number of streets available for both directional movements, the volume of those movements and by physical barriers which cannot be moved and can only be crossed at certain points.

Relation to Traffic Needs

Although each expressway carries a major highway through the city, the location within the city, and in several cases, for several miles beyond the city limits was not controlled by that feature. The primary basis of design studies has been to locate the arteries where they will serve the greatest volume of traffic most efficiently. Extensive and comprehensive traffic studies were made, based upon land use and population density. Major traffic-generating areas were determined. Existing and proposed city arteries were studied to determine which of these should be selected to cross the expressway at points of interchange, for collection and dispersal of traffic.

Transition from the Four-street System to the Expressway

Functional Design of all Structures Effected Maximum Economy as well as Pleasing Appearance

Design Standards

Design standards conform as closely as practicable with those set up by the A.A.S.H.O. The only deviation is in minor details or where strict adherence would cause excessive cost in right of way or property damage. The structural designs do not include any intricate architectural effects. The design is strictly functional with simple flowing lines, combining graceful slenderness with adequate strength.

Because of the flat terrain and the shallow depth of the water table overpasses have been generally used. Where drainage conditions warranted, the secondary artery has been depressed as much as practicable. In no instance has pumping been resorted to as the means of draining depressed streets since torrential rains occur during tropical storms when electric power lines may be out of service and other types of power have not proven entirely satisfactory.

All plans have been developed on the basis that any section must be adaptable to stage construction. All frontage or service roads have been designed for two-way traffic, but are readily adaptable for use as one-way arteries. In fact, when the first expressway section was placed in use, the frontage roads were operated as two-way streets but were later changed to one-way streets by the simple expedient of installing signs and adjusting traffic control signal faces.

Where traffic volumes do not justify, or available funds do not permit the construction of a complete expressway facility, either the service roads or the freeways may be built in the initial stage. In some cases a short section of the complete expressway, including an interchange, will be constructed with connections to the two 33-foot-wide service roads that then serve as two one-way arteries for a considerable distance. In another location a rotary is to be constructed with the service roads and intersecting city streets connected to it. The later stage will consist of the freeway roads and structure overpassing the rotary.

In all cases this procedure involves the acquisition of all rights of way prior to the construction of the first stage. This serves to prevent improvements by private interests upon land ultimately to be acquired and permits the construction of any addition to the initial stage at any time the need arises and funds are available.

Economic Factors-Division of Costs

All costs pertaining to rights of way and property damage are paid by the City of Houston. All costs of construction are borne jointly by the state and the Public Roads Administration in accordance with the usual Federal-Aid procedure. Drainage of the expressway and immediately adjacent areas is paid for by the state. Where practicable, existing trunk storm sewers are utilized for outfall mains. Where new trunk lines are required, the expense is borne jointly by the City and the State, the construction cost being divided on the basis of capacity required to drain the areas for which each agency is responsible.

The state has established a policy of maintaining all expressways including the lighting system. The city maintains the streets handling traffic to the expressways and all traffic control signals at the various traffic interchanges. Speed regulations and general features of traffic control, usually functions of the police department, are also handled by the city.

Savings to Motorists

The saving to motorists is the basic reason for building expressways and has been given much study. So many factors enter into these studies that planning engineers can, by weighting the factors in various ways, arrive at several widely divergent answers. The fact, however, remains that an urban expressway properly located and designed will effect a saving to the travelling public that would amortize the cost of installation in a few years. Travel time studies indicate that this period will not exceed 15 years and possibly will be much less.

The section now in operation is a sample of what may be expected of other sections as they are completed. This section totaling about four miles in length, built at a cost of approximately $7,000,000, is carrying a volume of 30,000 vehicles per day as recorded by automatic traffic counters. It overpasses three railroads, three main city arteries, and the four miles include the "Four Street System" described above. Travel time and speed delay studies were

Three Miles of Houston Urban Expressway with Four-street Distribution System Near Business Area in Background

Transition from the Expressway to the Four-street System

View of Expressway from Raised Median. Note Simplicity of Structure Rail and 16,000 Lumen Mercury Vapor Lamp Mountings

made over the city streets prior to opening the expressway and over the expressway after it was placed in operation.

The time saved is approximately 12 minutes. If the saving per vehicle is assumed to be as low as one cent per minute and there should be no increase in traffic volume, the saving would pay for the facility in less than ten years. As additional sections, however, are placed in operation, the traffic volume will increase. Traffic analysis indicates that this section will be carrying a volume of approximately 70,000 vehicles a day ten years hence if the entire facility is in operation prior to that time.

CONCLUSION

Those who study traffic and work on planning and design of expressways, particularly urban expressways, realize that the supply of adequate facilities will probably never catch up with the demand of traffic. Urban expressways are one of the greatest factors in decreasing traffic congestion in our cities. At the same time, an urban expressway is one of the greatest traffic generating media. Community centers develop in the vicinity of interchanges; industries, particularly warehouse and distributing agencies, are established along the expressways for they afford more ready access to other parts of the city.

No mention has been made in this article of the safety factor that is an essential element of all expressway design. This feature has been so widely and thoroughly discussed it has been purposely omitted. It is worthy of note, however, that in the ninety days of full operation of this section no fatal accidents have occurred. The only personal injury accident was to a pedestrian "jay-walking" across the freeways only a short distance from a safe crossing under an overpass where a sidewalk was provided for pedestrian traffic.

A few property damage accidents have occurred mostly by sideswipes resulting in crumpled fenders and none of a serious nature. Automatic traffic counters, continuously in operation during this period show an excess of ten million vehicle miles have been travelled over the freeways alone. The total volume, including the traffic on the frontage roads of which only occasional counts have been made, probably exceeds twelve million vehicle-miles.

Motor Vehicle Inspection

This article was prepared by the Staff of the Eno Foundation from information and materials compiled by T. F. Creedon, Eastern Zone Representative of the Automobile Manufacturers Association, Detroit, Michigan. For the last four years he has handled cooperative programs between the Association and agencies interested in safe and efficient use of the highways. Mr. Creedon was for nine years Assistant City Engineer in charge of planning and traffic engineering at Arlington, Massachusetts. For two years he was Director of the Community Safety, Division of the Massachusetts Safety Council, Boston, Massachusetts.

DEFECTIVE equipment causes 18 per cent of known highway accident fatalities—an increase of from 8 to 18 per cent in the last five years. A complete report of all accidents possible to obtain would probably make the proportion even higher.

Four elements, singly or in combination, are responsible for motor vehicle accidents: (1) the driver, (2) the pedestrian, (3) the highway, and (4) the vehicle. Efforts to reduce or eliminate mechanical failure, therefore, rank as an important part in the campaign to reduce accidents.

The 18 per cent item mentioned includes such causes as defective brakes, improper lights, faulty steering mechanisms, blowouts and worn tires, according to the National Safety Council in its 1947 issue of ACCIDENT FACTS.

Motor Vehicle Inspection

Compulsory motor vehicle inspection programs developed from the "Save-a-Life" campaigns begun in 1927, 1928, and 1929 by proclamations of the governors of Delaware, Maryland, Massachusetts, New Jersey, New York and Pennsylvania. These proclamations required motor vehicle owners during a specified period to present their vehicles for the inspection and repair of all safety equipment.

In 1929, Maryland, Massachusetts and Pennsylvania enacted laws requiring state-wide periodic inspection of motor vehicles. In 1930, the six New England states joined in a united program for promoting street and highway safety through periodic inspection.

A brief history of the development of motor vehicle inspection in the United States follows:

1927: New York, Massachusetts, and Maryland were the first states to inspect vehicles as a part of their "Save-a-Life" campaigns.

1928: Pennsylvania, New Jersey, and Massachusetts conducted "Save-a-Life" campaigns.

1929: Delaware, Maryland, Pennsylvania, and New Jersey conducted "Save-a-Life" campaigns.[1] Pennsylvania, Maryland and Massachusetts enacted laws for state-wide periodic inspection of motor vehicles.

1930: Six New England States—Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, and Connecticut—joined in a united program for promotion of street and highway safety through motor vehicle inspection. Pennsylvania, Maryland and Massachusetts initiated state-wide inspection programs through officially appointed garages.

1931: New Hampshire initiated state-appointed garage-type inspections.

1932: Virginia initiated state-wide periodic inspection of motor vehicles.

1933: Delaware initiated first state-owned and operated inspection systems.

1934: Motor vehicle inspections became a part of Act V of the Uniform Vehicle Code and were approved by the National Conference on Street and Highway Safety. Memphis, Tennessee, was the first city to install a city-owned-and-operated inspection system for all registered cars.

1935: Colorado and Vermont initiated officially-appointed garage-type inspection systems. Des Moines, Iowa, and Evanston, Illinois installed city-owned-and-operated inspection systems.

1936: Omaha, Nebraska and Portland, Oregon initiated city inspection systems. The City of Chicago began inspection of motor vehicles.

[1] The early "Save-a-Life" campaigns were instituted by proclamation of the governor of each state requiring all owners of motor vehicles during a stated period ranging from two to three weeks, to present their automobiles to designated garages for a complete inspection and repair of all safety equipment. These campaigns were the forerunners of present-day periodic motor vehicle inspection programs.

1937: American Association of Motor Vehicle Administrators and National Conservation Bureau sponsored the development of the Motor Vehicle Inspection Code—under procedure of the American Standard Association.

1938: Inspection Section of Act V, Uniform Vehicle Code, was revised and approved by the National Conference on Street and Highway Safety. New Jersey and Washington opened state-owned-and-operated systems of inspections. Lincoln, Nebraska, initiated city-owned-and-operated system of inspection.

1939: Motor Vehicle Inspection Code was approved by the American Standards Association. American Association of Motor Vehicle Administrators and the National Conservation Bureau began preparation of the Motor Vehicle Inspection Manual.

District of Columbia instituted District-owned-and-operated inspection systems. Miami Beach, Florida, installed city-owned-and-operated inspection system.

1940: Motor Vehicle Inspection Manual was completed and officially endorsed by the American Association of Motor Vehicle Administrators.[2] South Carolina established a state-owned-and-operated inspection system. Inspections applicable only to Commercial Vehicles were extended to include all types of vehicles.

Illinois established a garage-type system for trucks only. Cincinnati, Ohio, established a city-owned-and-operated system of inspections.

Seventeen states and fifteen cities were requiring periodic inspection of some 8.5 million vehicles each inspection period. Brake Sub-Committee of the Motor Vehicle Inspection Code Committee initiated special study of passenger and commercial vehicle brakes.

2 The Motor Vehicle Inspection Manual of 118 pages, including the Motor Vehicle Inspection Code, is divided into six chapters dealing successively with: (1) Development of Motor Vehicle Inspection; (2) Legislation; (3) State and municipally owned and operated stations; (4) State appointed stations; (5) Combination of state-owned and state-appointed inspection program, and (6) Approved code of standard inspection requirements for motor vehicles.

The Code set forth in Chapter 6 of the Manual provides numerous standards for the safe performance of motor vehicles. The Manual deals with establishment of motor vehicle inspection systems with its numerous legal, organizational and administrative aspects. Thus, the Manual provides a practical means for operation of the code and has been found to be invaluable to officials interested in organizing and operating an inspection program economically and efficiently.

The U. S. Public Roads Administration, through its facilities, instituted program of research into motor vehicle brakes, the brake sub-committee acting as advisors.

1941: Pearl Harbor, and many inspection programs were curtailed for the duration of the war.

1944: Need for inclusion of Motor Vehicle Inspections as part of "post war" traffic safety plan became increasingly apparent due to unsafe condition of motor vehicles resulting from war-time shortages of man-power and materials.

1945: Minnesota legislature, "authorized and required the Commissioner of Motor Vehicles to designate, furnish instructions to and supervise official stations for adjusting head lamps and auxiliary driving lamps and official stations for testing brakes to conform with provisions of the act." This act, with reference to official stations for testing brakes shall not become effective until six months after the duration of the war. Massachusetts legislature amended the inspection law authorizing the Registrar to make regulations governing equipment and construction of school buses.

New Hampshire legislature amended the inspection law to provide for inspection of all buses carrying more than 10 school children. The new law, effective July 1, 1945, involved the annual inspection of approximately 270 vehicles of the school bus type.

Washington legislature removed inspection activity from control of the State Highway Department and vested such authority in the Washington State patrol. A budget was approved by the legislature for reopening of inspection stations on a full pre-war schedule immediately upon close of the war.

National Safety Check Program

Following a successful experiment in Michigan, the International Association of Chiefs of Police, in cooperation with manufacturers, dealers and the automotive industry, inaugurated a brake check program in 1945. This program proved so successful that in 1946 a national safety check program was launched, for inspection of wind shield wipers, tires, lights, steering mechanism, and brakes.

During the six-weeks program ending June 1, 1945, the brakes

of 1,664,317 vehicles were inspected. About one-seventh of these vehicles, or 241,998 were found below the brake-check standards. Owners were requested to make repairs.

In states having good motor vehicle inspection programs, only a small percentage of the vehicles checked were found to have inadequate brakes. In one state not requiring inspection, 27.7 per cent of the vehicles checked had poor brakes, while in the District of Columbia, Massachusetts, and New Jersey, where sound inspection programs are operating, the percentage of vehicles found with poor brakes was 2.9, 3.7, and 5.6 per cent, respectively.

Findings in the 1945 program should not be interpreted to mean that 85 per cent of our vehicles have adequate brakes. In states having inspection programs, experience over a period of years has shown that from 40 to 60 per cent of all cars have defective brakes.

Another significant feature of the program was that one state during the six-weeks check period experienced its lowest fatality record. Many other states and municipalities achieved substantial reduction in traffic accidents during the program.

Nearly One-Third of Vehicles Defective

During the 1946 safety check program conducted from May 15 through July 7, a total of 2,718,076 vehicles were checked by the police. Of this number, 872,290 or 32.1 per cent had obvious defects affecting safe operation. Faulty lighting, front and rear, led the list of defects. Inadequate brakes were next in order of frequency.

Traffic fatalities during May, June and July, 1946 were about 20 percent lower than in the same months of 1941, whereas fatalities during the first four months of 1946 were about the same as in the first four months of 1941. These figures indicate that the Police Traffic Safety Check and other safety drives in May, June and July reduced traffic fatality totals one-fifth below what early 1946 experience suggested that they might have been. This represents a saving of about 2,000 lives during the three-month period.

The main purpose of periodic vehicle inspection is to discover dangerous maladjustments and to prevent accidents by correcting

the defects. That is not the sole benefit, however. According to authorities, numerous others are derived from vehicle inspection.

Poll Favors Periodic Inspection

A public poll was sponsored by the National Committee for Traffic Safety to determine the public attitude toward periodic vehicle inspection. *Ninety-seven per cent of the persons interviewed favored periodic inspection of all motor vehicles.* This decisive position was registered as strongly in states that never adopted the requirement as in states that have regular inspection programs.

Motor Vehicle Inspection Policies

The position of the Automobile Manufacturers Association is indicated by its support of the Uniform Traffic Code, Article 5. The Automotive Safety Foundation and National Highway Users' Conference have actively supported periodic compulsory motor vehicle inspection.

Divided opinion exists among various state and local American Automobile Association clubs. The National Board of the AAA has endorsed motor vehicle inspection in principle but only in stations operated by government units.

In 1937 when the New Jersey Motor Vehicle Inspection Statute was presented to the legislature, the Keystone Auto Club of Pennsylvania protested the enabling bill. In 1947, the Keystone Automobile Club passed a resolution citing the advantages of motor vehicle inspection.

At present, statutes requiring motor vehicle inspection on a statewide basis are on the books of the following states:

> Colorado, Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, Mississippi, New Hampshire, (partially active), New Jersey, New Mexico, Pennsylvania, South Carolina, (partially active) Utah, Vermont, Virginia, and Washington

Connecticut, South Carolina and Virginia discontinued their inspection programs during the war and have yet to resume them.

South Carolina was to revive its program six months after the end of the war, but the legislature postponed revival until March 2, 1947.

Several other states have enacted statutes permitting cities to require motor vehicle inspection. Table I lists the agency responsible for motor vehicle inspection in the sixteen states and the District of Columbia that have inspection programs.

Table I

AGENCY OR INDIVIDUAL RESPONSIBLE FOR MOTOR VEHICLE INSPECTION

STATE-OWNED STATIONS

State	*Responsible Agency*
Connecticut	Commissioner of Motor Vehicles
Delaware	Motor Vehicle Department
New Jersey	Motor Vehicle Commissioner
South Carolina	Highway Department
Washington	Commission on Equipment*

STATE-APPOINTED STATIONS

Colorado	Motor Vehicle Department
Maine	Secretary of State
Maryland	Department of Motor Vehicles
Massachusetts	Registrar of Motor Vehicles
Mississippi	Commissioner of Public Safety
New Hampshire	Commissioner of Motor Vehicles
New Mexico	Vehicle Commissioner
Pennsylvania	Secretary of Revenue
Utah	State Road Commission
Vermont	Commissioner of Motor Vehicles
Virginia	Director of the Division of Motor Vehicles
District of Columbia	Director of Department of Vehicles and Traffic

State Inspection Programs That Failed

In 1939, Arkansas and Nebraska repealed their motor vehicle inspection statutes. The reason assigned was that the inspections burdened the people, caused unnecessary trouble and inconvenience, and also disrespect for general highway regulations. The fact probably is

* Consists of Director of licenses, Director of Highway and Chief of State Patrol.

that the states were not ready for inspection programs. National authorities recommended, and the Motor Vehicle Administration Committee of the President's Highway Conference agrees that:

> No State or municipality should undertake establishment of an inspection system until there has been successfully developed an adequate over-all accident-prevention program. This includes such essentials as standard driver licensing and examination, accident reporting, a program for highway construction and improvement, competent traffic engineering and safety education, all backed by efficient enforcement. Having once provided these basic requirements, however, full realization of the objective of accident prevention cannot be attained without the inclusion of periodic motor vehicle inspection as an essential part of the program.[3]

The Action Program of the President's Highway Safety Conference made the following recommendation:

> Establishment, in those States where an adequate over-all accident prevention program has been provided, of periodic motor vehicle inspection, on the basis of minimum standards prescribed in Act V of the Uniform Vehicle Code.

The Motor Vehicle Administration Committee of the President's Highway Safety Conference carefully considered the matter of periodic motor-vehicle inspection. It concluded that a motor vehicle administration program fully geared to highway safety objectives includes four basic elements that can effectively assist in preventing traffic accidents. One element is this:

> Through motor vehicle inspection, it provides a periodic check on the operating condition of the vehicle, and serves to make motorists more keenly aware of the importance of safe driving attitudes and of their individual responsibilities in accident prevention.

This Committee's recommendation advocated vehicle inspection, but did not specify any particular system for adoption by the states. Recommendations, however, do specify adherence to the Uniform Motor Vehicle Code which, in itself, does not specify any system but like the Committee's recommendations leaves the determination to each individual state.

[3] Report of Committee on Motor Vehicle Administration, President's Highway Safety Conference, 1946.

Three Types of Inspection Systems

With some exceptions, expert opinion favors vehicle inspection. A sharp distinction however has arisen as to which system should be employed. Motor vehicle inspection programs have developed these three distinct categories:

1. A. *State Owned and Operated Stations.* Under this system, the State buys or leases buildings, purchases the equipment, hires supervisors and inspectors and has complete jurisdiction over the entire operation of the stations. In certain States portable stations are used in rural areas. The States using this method are: Connecticut, Delaware, District of Columbia, New Jersey, South Carolina, Washington. Washington is unique in its system, being the only State to use mobile stations in making checks.

b. *Municipally Owned and Operated Stations.* This type operates under a city ordinance and a State enabling act permitting a municipality of a certain size to conduct its own inspection program. States using this method are: Alabama, Florida, Illinois, Iowa, Minnesota, Montana, Nebraska, Ohio, Oregon, Tennessee.

2. *Private Stations Appointed by the State.* In this case the stations operate under an inspection law empowering the State to appoint garages or service stations to conduct inspections under rules and regulations established by the State. States using this method are: Colorado, Maine, Maryland, Massachusetts, Mississippi, New Hampshire, New Mexico, Pennsylvania, Utah, Vermont, Virginia.

3. *Combinations of Official Systems.* This system combines both system one and two, using both State owned and operated stations and private stations. Usually the private stations are used in rural districts. At the present time, no States are using this method.

State Operated Systems vs. Appointed Systems

Previously mentioned systems were studied and analyzed by the Motor Vehicle Administration Committee of the President's Highway Safety Conference, and their findings were substantially as follows:

> **The quality of the inspection job in some States and cities is equal to or better than that required in the minimum standards set forth**

in the "Motor Vehicle Inspection Manual." However, in the majority of cases, the quality of the inspection job is poor. The committee concluded that generally the best job was being done by stations owned and operated by the state and assigned the following main reasons for failure under each system:

State Owned and Operated Stations:

1. Failure to receive a fair share of revenues to perform the service for which its fees are collected.
2. Salary scales inadequate to attract and hold personnel of the desired qualifications.
3. Lack of sufficient personnel.

Cities Operating Under Enabling Acts and Local Ordinances:

1. Failure to receive a fair share of operating revenues from the fee collected.
2. Inadequate salary scales.
3. Lack of adequate jurisdiction.
4. Lack of job security.

States Operating Under State Appointed Systems:

1. Inefficiency and inadequacy of this type of operation.
2. Lack of fundamental honesty on the part of some segments of the licensed garages and its corrupting influence on others.
3. Inability to maintain responsibility commensurate with authority exercised.

The following sections discuss each individual system and include the arguments, merits and benefits attributable to each, as well as the disadvantages and objections that are raised.

Benefits of Vehicle Inspection

It is argued that the following major benefits result from motor vehicle inspection:

1. It improves the general standard of vehicle condition.
2. It maintains an automobile at a higher value level by lessening depreciation.
3. It affords opportunity to check motor and serial numbers actually on the vehicles against registration certificates and in other ways assist in the enforcement of motor vehicle laws.

4. It improves the quality of garage workmanship in making adjustments and repairs.

5. It provides an excellent opportunity for informing drivers about the condition of their cars and their responsibility for driving safely 365 days in the year.

6. The psychological effect on the driver is considerable. The motorist who has been shown that his brakes meet only the minimum requirements will tend to drive more carefully.

7. Inspections also help to keep car owners aware that certain parts need periodic attention and that it is less expensive to have the vehicle checked regularly and kept in repair than to wait until a breakdown occurs.

8. Rejection of a vehicle usually informs the motorist in a specific way that he is driving an unsafe car, and that as a consequence he is liable to be held as the negligent party in the event of a collision with a car that has been properly maintained.

9. The driver who subjects his car to periodic inspection tends to cooperate with enforcement officers and the general public in the observance of traffic rules and regulations.

10. Periodic inspection provides for the motorist an inexpensive maintenance service not available elsewhere.

Arguments Against Inspection

1. A financial burden on the public.

2. Has a high nuisance value due to public inconvenience during inspection periods—especially in State Owned and Operated Stations.

3. Permits politicians to control inspection activities and therefore opens the door for potential grafting.

4. Automobile dealers, operators of repair shops and service stations have an opportunity to gouge the public by making unnecessary repairs or by charging excessively for services rendered or exacting high prices for condemned parts, which had to be replaced before inspection approval.

5. Motor vehicle inspection adds just one more function to government in the march toward totalitarianism.

The Case for State Owned and Operated System

This system is the most effective and economical to administer because:

1. It places the inspection of motor vehicles under direct supervision of the state or local government through appointment of inspectors trained and employed by the state or city.

2. It assures uniform inspection of all vehicles according to standards and regulations adopted and promulgated by the state or city.

3. It creates a fair practice plan under which the government agency administering the program instructs the motor vehicle owner as to what repairs are necessary, before approval can be given, leaving it to the owner or operators of the vehicle to choose his place or method of obtaining such repairs.

4. States and cities having this type of program report it to be self-sustaining at a fee basis approximating 50 cents an inspection.

5. Places safety before commercialism.

6. Standardizes inspections and results in greater safety.

7. Checks on the quality of work delivered by the garage.

8. Provides a means for distributing safe driving information.

9. Provides a headquarters for driver education, examination and license.

10. Stops unethical sale and delivery of unsafe, ramshackle used cars.

11. Provides a Safety test available to motorist any day in the year for the one annual inspection fee.

12. Makes the police power of the inspector available to enforce compliance.

Arguments Against the State Owned and Operated System

1. State owned and operated systems are being applied satisfactorily and economically only in a limited number of states that have a high motor vehicle registration density.

2. State owned and operated systems are encroachments on private enterprise and an imposition of a governmental set-up at the expense of the taxpayers.

3. The State owned and operated system involves a "lane" type of inspection which does not lend itself to careful consideration of the condition of the vehicle by an expert mechanic.

Advantages to Dealers and Garages

1. Relieves garage of inspection responsibilities, particularly with friends and customers.

2. Eliminates pressure from good customers to obtain "OK" for unsafe vehicles.

3. Only one answer to safety condition of the vehicle.

4. Provides a check on and increases the efficiency of mechanics.

5. Results in more service work for the competent shop than the certified station plan affords.

6. Provides use of inspection equipment for small dealers and garages who cannot afford a completely equipped shop.

7. Provides a constant flow of safety service work through the year.

8. Trained supervisors available to all to advise on safety service.

9. Tends to solve the problem of the "fly-by-night alley" shop.

10. Prevents public from shopping about to obtain a certificate without examination.

11. Stops unethical sale of unsafe used cars.

12. Leaves shop free of congestion and possible financial loss on inspection of vehicles in good condition not requiring service.

13. Requires motorist to put vehicle in safe condition if he is to operate vehicle on public highways.

The Case for State Appointed Station System

1. It would further the interest of private enterprise. It would preserve all elements of free enterprise in the administration of inspection programs.

2. Such a system conscientiously administered has an opportunity to perform a more thoroughgoing inspection of the vehicle.

3. It eliminates the expense to taxpayers of special governmental equipment, facilities and personnel.

4. This system would be the more convenient to vehicle owners permitting the owners to have the inspection made and any repairs or adjustments taken care of by the dealer or garage with which he normally does business.

5. More easily organized, since service stations and garages are already in existence which are capable of conducting inspections with few additions of testing equipment.

6. Stations are designated in each locality throughout the state, thus furnishing state-wide service and requiring motorists to travel a minimum distance for inspection of their vehicles.

7. A much larger number of stations than are possible in the state-operated system permits concentration of inspection periods into the shortest possible time that is most effective in arousing public interest, securing cooperation and compliance, and facilitation of enforcement.

Disadvantages of the State Appointed Station System

1. It sets up a source of discrimination, at the pleasure of the state, among businessmen engaged in the sale and repair of automobiles.

2. The fee for inspection must necessarily be excessive in order to justify devotion of the time of repair shop personnel to this type of work.

3. More business is lost than gained by the conscientious operator because of improper practices employed by some appointees. This results in vehicles' being disapproved by the conscientious operator and subsequently approved by some unscrupulous station.

4. Under this system it is impossible to administer the inspection regulations uniformly because it is entirely impracticable to provide necessary supervision. For example, Pennsylvania, which probably administers the best program of this type in the United States, has had 40 specially trained State policemen devoting full time to the supervision of some 7,000 stations. Notwithstanding this rather unusual provision, the program does not have the desired effect because it is not administered uniformly; bad practices still exist and in not a few cases official stickers may be purchased on the sidewalk in some cities.

5. Politics cannot be kept out of appointments. Appointments are often withdrawn or suspended for cause and later restored before the period of suspension has expired or before the station has complied with regulations on ground of political consideration. It has been predicted that this is a condition that will always be present under this type of program.

6. It is difficult, if not impossible, to require privately owned and operated stations to acquire and maintain the kind and type of equipment necessary to the proper inspection of the motor vehicle. It is likewise difficult, if not impossible, to require that the privately owned station provide the proper type of personnel engaged in inspection work.

7. It is unsound for state government to embark upon a program that involves the enforcement of laws by businessmen. Persons engaged in the conduct of a business are businessmen first. Any other function they may acquire as an incident to that business must be relegated to a secondary position. Take the case of an automobile dealer, and a customer of long standing who suddenly finds himself in difficulty over the matter of inspection and approval. There is a good chance the dealer will provide the good customer with an approved certificate notwithstanding the fact that there may not be time to conduct a proper inspection.

8. The validity of the argument that the state owned and operated plan competes with automobile dealers and repairmen is unsound for vehicle inspection can only be justified on grounds of safety and hence is an exercise of the police power of the state.

9. That private stations can give a more thorough-going inspection is unsound because it is not practical for the owner of a privately operated station to permit his mechanics to devote a great amount of time to an inspection in view of such a practice involving the assessment of a fee which easily becomes so high as to be objectionable.

Statewide Origin-Destination Survey for Traffic in Arizona

WILLIAM E. WILLEY

Mr. Willey, since 1933 with the Arizona Highway Department, has been Engineer of the Division of Economics and Statistics since 1946. He was previously with the Bridge Division for eight years. The new Economics and Statistics Department was an outgrowth of the original Statewide Highway Planning Survey. Mr. Willey is an Associate Member of the American Society of Civil Engineers.

To become acquainted with the part traffic plays in the design and administration of a well-established highway system, it is necessary to know what traffic does, where it goes, what problems arise because of traffic increases, and for what principal purposes traffic uses the highways.

Of the great number of traffic studies of various kinds, the most successful, it is thought, is the driver-interview type of origin-destination survey. As this method had been highly satisfactory on a small scale, it was believed in Arizona that a *statewide* origin-destination traffic survey could be of great value both now and in the future.

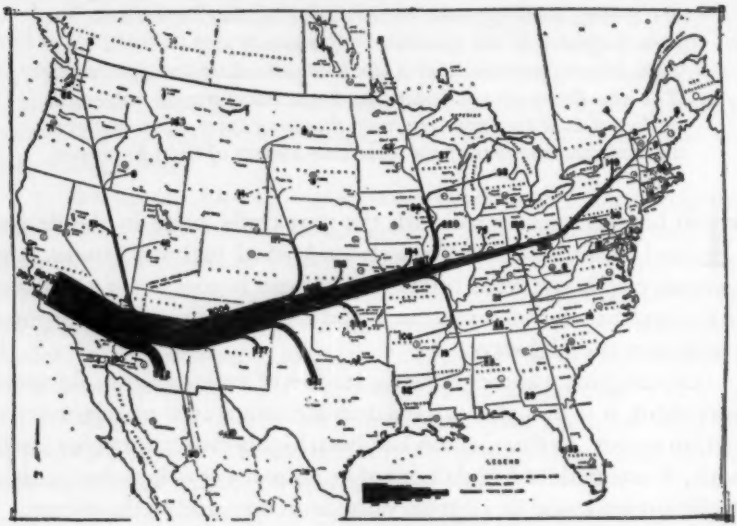
Consequently, a statewide origin-destination traffic survey covering a period of one year was started in April, 1948. The year was divided into four seasons and a complete cycle of the state scheduled for each season. In other words, interview stations will be operated four times. Arizona is a great tourist state. The seasonal check will determine the variation in seasonal traffic demands.

Desire lines may reverse themselves between Summer and Winter when results are completely analyzed. This is a factor not known at present, and only an extensive survey will produce the answer.

The proper programming of available funds will provide for developments that will serve the needs of the state as well as those of the transcontinental motorist. Out-of-state cars contribute a major portion of all traffic on state and urban highways. The study will provide the necessary information for a thorough traffic analysis

within the state, and will also enable the department to show by traffic desire bands, and to make a study of, interstate travel of a transcontinental nature.

From a national standpoint, the transcontinental desire line map discloses many things. In addition to the usual engineering and statistical analyses that will be made, various Chamber of Commerce



and business organizations are seeing for the first time definite fruits of their advertising campaign to bring tourists into the state.

They can also determine, from a study of the map, the areas of the United States where it would be to their advantage to spend more money for advertising to attract additional motorists to the many scenic wonders of the southwest.

Zone Control

In the planning and setting up of a survey of this character, care must be taken to zone the state properly and correctly so that traffic movements can be shown with respect to the present and future needs for highway development. In many cases, a state could be zoned by a grid system of sections, zones and sub-zones, the zones and sub-zones

being of a uniform shape and size, and conforming with parallels and meridians. Features of an economic and geographic nature within a state, however, could well be the reason for zoning differently.

In Arizona, there are many natural barriers and boundaries—mountain ranges, high rims or bluffs, rivers, canyons, and wide, isolated desert areas. For this reason, in the zoning plan for Arizona, sections were indicated showing a population density that would indicate "potential traffic generating areas." Great care was taken not to include an area so great it would be cumbersome for detailed traffic studies.

Zone boundaries were established as shown on the state map. Each zone included two or more of the "potential traffic generating areas." The zone boundaries, as much as possible, conformed to mountain ranges, rivers, and so forth, or county boundaries. Within each zone, there were established sub-zones, as many in number as required to separate each potential traffic generating area from the other. Arizona consists of 113,580 square miles and contains approximately 4,000 miles of state highway within the fourteen counties. This area was divided into twenty-one zones and forty-four sub-zones. Outside of the state, and in adjoining states, twenty-two sub-zones were located, each situated so as to include one of the important roads affording entrance to and departure from Arizona.

Operation

When making the initial preparations for the origin-destination traffic survey, special attention was given to the selection of men making up the field survey party. Competent and experienced people were chosen since they represent the state in the eyes of the motoring public.

In the Arizona Survey the party consists of a Field Supervisor, or Party Chief; a Manual Traffic Recorder, or Classifier; two Roadside Interviewers; an Operator of Automatic Traffic Counting Machines; a Utility Man, or Substitute, and a Traffic Supervisor, or Traffic Officer.

The duties of each man in the party were well defined and those duties had to be fulfilled so the party could operate successfully.

The Field Supervisor, or Party Chief, must be a man who has had considerable experience in making field traffic surveys and studies. His duties include being in charge of all activities pertaining to field operation of the survey and keeping a close check on the members of the party and the data obtained while the interview station is in operation.

The Manual Traffic Recorder, or Classifier, manually counts all traffic going through the station and makes complete classification of such traffic as to vehicle types. His count is used importantly when obtaining the expansion factor raising the traffic count from the sixteen hour period to an average twenty-four hour day.

The Interviewers must be men who can meet the public, obtain the necessary information and not arouse an antagonistic spirit in the motorist because he is being stopped and questioned. The data on the interview sheet must be correct and complete in order to show the definite origin and destination of each vehicle trip. Interviewers are instructed to always be extremely courteous and never neglect to thank the motorist for his cooperation in the traffic survey.

The Operator of Automatic Traffic Counting Machines must be familiar with the machines, the installation and maintenance of them, and must make sure that they are operating satisfactorily. The traffic count is registered on a recording tape for at least twenty-four hours.

The Utility Man, or Substitute, fills in for an Interviewer or the Manual Traffic Recorder during an absence, and is a buffer against illness or accident.

The Traffic Supervisor, or Traffic Officer, should be a man fully capable of handling traffic in all its phases. In Arizona he was commissioned as an officer, with certain limited powers, by the Superintendent of the Motor Vehicle Division. In his position on the survey party, he stops traffic, tells the motorist what the stop is for, hands him a printed card which outlines the purpose of the traffic survey, and directs him to the Interviewer. The Traffic Officer like the Interviewer must also be courteous when dealing with the traveling public.

In addition to the field party, a competent force is required in the

central office, consisting of an analyst with coders, typists, punch machine and tabulator operators and a draftsman.

Study and Analysis

The data obtained in the field will show the volume of traffic which desires to make certain trips having a specific origin and destination.

Field information is recorded at hourly intervals, on the hour. The Party Chief collects all interview sheets and traffic figures each hour and prepares them in separate bundles for transmitting to the office. In this manner the maze of information is kept in an orderly fashion and is easily analyzed when sent in. Without this definite system, the interview sheets would soon become a jumbled mass of incoherent information requiring many man-hours to re-sort and place in proper hourly sequence by stations.

Each station was normally operated 16 hours in two periods of eight hours each (6AM to 2PM, and 2PM to 10PM.) Traffic characteristics in Arizona are such that approximately 85 percent of the total twenty-four-hour vehicular-count pass the station during these two shifts. It is necessary therefore, to expand the sixteen-hour count to represent an average twenty-four-hour day by applying a factor of expansion. The following formulae is used:

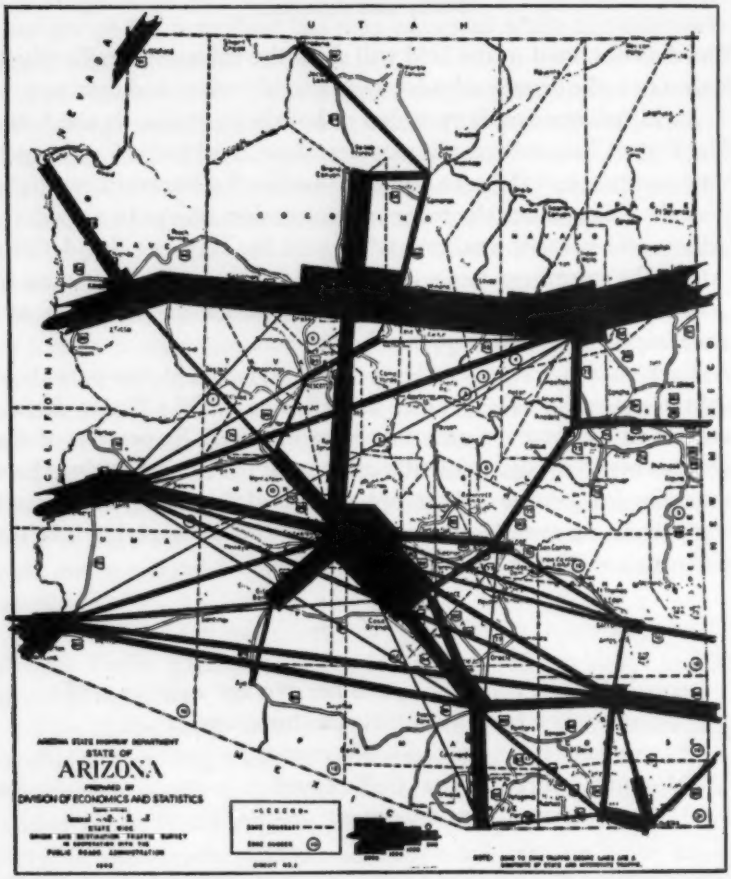
$$\frac{A}{A_1} \times \frac{M}{I}$$

equals Factor, where A equals the average 24-hour traffic count taken from automatic machine tape.
A_1 equals 16 hour manual traffic count.
M equals hourly manual traffic count.
I equals hourly interview count.

This operation will result in a factor for each hour and, when coding the interview sheets, it will be used by the tabulator in raising the traffic count. After cards are punched, proofed, and corrected, the count at each station is machine-tabulated. From this data, definite desire-lines can be shown indicating the traffic flow bands, as the

desire-lines will not follow any highway or route but will go from point of origin to point of destination for each trip.

From the map showing the traffic desire-line bands, one can see



the density of such traffic movements, and the sections of highways that need improvement now, or soon will, or possible relocation with modern design. For better visual presentation, individual desire-lines, or trip data, were combined by geometric methods to form composite maps. To the layman and average engineer or highway

administrator this type of presentation is more easily understood than the usual spider-web pattern.

From time to time, there arises a need for a special traffic study within a limited area for the purpose of ascertaining whether or not there is economic justification for a cut-off road, a new route, or a shorter route. The information obtained from the statewide origin-destination traffic survey can be enlarged upon by setting up a few additional interview stations. This is helpful, from an economic standpoint in planning new routes.

From the trip information between zones, it is possible to assign potential traffic to a new route and then determine the economic benefit ratio. That is, if benefits for the motorist from time and mileage saved are greater than the cost of construction and maintenance, then the new route is economically feasible.

This method shows the total annual vehicle operation cost for the mileage saved along the proposed route as compared with the corresponding ownership cost. A ratio of greater than one to one in favor of the vehicle operating cost will indicate an economic justification for the proposed project. It does not tell the whole story however. Such other things as the total state highway mileage against the total revenue available, as well as the economy of the state as a whole, must also be considered. Three such routes are under construction in Arizona, so the system is producing definite results.

Highway Administration

Traffic studies such as this, will furnish factual information and data valuable in setting up long-range highway planning. An economic study was recently made between Phoenix and Tucson. It resulted in selecting a much better highway route than those existing.

Planning for the state or phase construction of this new highway within a certain period of time has also been decided upon. Funds for the construction of the first section, twenty miles in length, are set up in this year's construction budget. At the time it was made, this survey, extending over a distance of 123 miles, was said to be the first origin-destination survey of this magnitude attempted by any state.

It has been found, on many occasions, that political influence and local pressure groups interfere to some degree with sound highway planning, especially when the best and most economical location for a new route is to be determined. With the data obtained from a statewide origin-destination traffic survey, and the maps and tables formulated therefrom, much of this influence can be overcome by showing in a businesslike manner and from an economic standpoint, where a new route for the highway should be, what potential traffic it will carry, and benefits that will be afforded the motoring public.

At the same time, the statewide origin-destination survey will aid materially in making local urban studies for the improvement of traffic facilities within cities and in some cases will determine when a by-pass route becomes necessary. The statewide project follows the same general pattern and technique used in local studies now being conducted in the Phoenix and Tucson metropolitan areas. The results of the local studies will be correlated with, and partly included in the final report, thereby serving as a double check on the major desire-lines within the state.

Expansion of Study

In obtaining the traffic data through the statewide origin-destination survey, the work may be broadened to include additional financial and trip information for study and analysis, as well as any other detailed data that might be desired. For instance, interstate trip cost information can be obtained during the roadside interview by handing the motorist a questionnaire and return envelope with pre-paid postage.

Such a survey is being made in Arizona. The field work is being done by the statewide O-D party. Stations "M", "L", and "D-D" along a line near the west boundary of the state, were selected from which to hand out questionnaires. Station "M" has been operated; 400 questionnaires were distributed. For this one station, 139 were mailed back—a return of 34.8 percent—very good for this type of survey. Of the number returned, 106, or 77.9 percent were complete as to information desired. The results of the financial aspect of this program will be the subject of a special analysis and will be published in a separate report.

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